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Development of an Item Unique Identification Strategy for the Legacy Components of the US Marine Corps M1A1 Abrams Tank

03 December 2008

by

Edward Y. Blakiston, Maj., USMC

Carl J. Punzel, Capt., USMC, and

Richard A. Jennings, Capt., USMC

Advisors: Dr. Geraldo Ferrer, Associate Professor

Dr. Daniel A. Nussbaum, Professor

Graduate School of Business & Public Policy

Naval Postgraduate School

Prepared for: Naval Postgraduate School, Monterey, California 93943

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Abstract

The Office of the Secretary of Defense (OSD) has mandated that every component that meets certain cost and management criteria in the Department of Defense's (DoD) tangible inventory must have a valid Item Unique Identification (IUID) mark by December 2010. The IUID program is expected to increase force readiness, enhance the lifecycle management of assets, and provide more accurate asset valuation to achieve unqualified audit opinions on DoD financial statements. One of the challenges of the program is to achieve IUID-marking saturation throughout in-use, or legacy, inventories with minimal interruption of operational readiness. The purpose of this project is to propose an effective implementation strategy for the legacy items that meet the DoD's requirements for IUID marking in the US Marine Corps M1A1 Abrams tank community. This plan could potentially serve as a model for other communities facing the challenge of IUID implementation. This project examines different implementation alternatives and identifies and develops the determined best course of action. In addition, this project provides an estimation of the costs to implement the chosen plan for comparison and decision-making purposes.

Keywords: Item Unique Identification, IUID, Legacy Components, M1A1 Abrams MBT, *CFO Act 1990*

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About the Authors

Major Edward Y Blakiston, United States Marine Corps, is currently a student in the Master of Business Administration program (with an emphasis on Financial Management) at Naval Postgraduate School, Monterey, California. Major Blakiston completed his undergraduate studies at University of Florida in Gainesville, Florida. Prior to his current assignment, Major Blakiston served as a Company Commander and Battalion Operations Officer for 2d Tank Battalion, 2d Marine Division in Camp LeJeune, North Carolina. His next assignment is to the Program and Resources Division, Headquarters Marine Corps, Arlington, Virginia.

Captain Carl Punzel, United States Marine Corps, is currently a student in the Master of Business Administration program (with an emphasis on Material Logistics Support) at Naval Postgraduate School, Monterey, California. Captain Punzel completed his undergraduate studies at University of Arizona in Tucson, Arizona. Prior to his current assignment, Captain Punzel served as the Aviation Supply Officer for Marine Aviation Logistics Squadron 13 at Marine Corps Air Station Yuma, Arizona. His next assignment is to Marine Corps Logistics Base, Albany, Georgia.

Captain Richard Jennings, United States Marine Corps, is currently a student in the Master of Business Administration program (with an emphasis on Material Logistics Support) at Naval Postgraduate School, Monterey, California. Captain Jennings completed his undergraduate studies at University of Arizona in Tucson, Arizona. Prior to his current assignment, Captain Jennings served as a Company Commander and the Ground Supply Officer for 1st Light Armored Reconnaissance Battalion, 1st Marine Division in Camp Pendleton, California. His next assignment is to Marine Corps Logistics Base, Albany, Georgia.

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List of Acronyms and Abbreviations

2D	Two-dimensional
2d	Second
AIT	Automated Identification Technology
ANAD	Anniston Army Depot
ASA (FM&C)	Assistant Secretary of the Army (Financial Management and Comptroller)
ATGW	Anti-tank Guided Weapon
BIC	Blount Island Command
CAX	Combined Arms Exercise
CCB	Configuration Control Board
CFO	Chief Financial Officer
CLEI	Common Language Equipment Identifier
CO_2	Carbon Dioxide
COA	Course of Action
CVE	Combat Vehicle Evacuation
DMFA	Depot Maintenance Float Allowance
DoD	Department of Defense
DPM	Direct Part Marking
DU	Depleted Uranium
DWFK	Deep Water Fording Kit
ECP	Engineering Change Proposal
EEAP	Enhanced Equipment Allowance Pool
FASAB	Federal Accounting Standards Advisory Board
FEP	Firepower Enhancement Program
FIS	Forward in Stores
FLIR	Forward-looking Infrared
FOC	Full Operating Capability
FTL	Far-target Locater
FY	Fiscal Year
GAAP	Generally Accepted Accounting Principles
GAO	Government Accountability Office
GCSS-MC	Global Combat Support System-Marine Corps
GPP&E	General Property, Plant and Equipment
GPS	Gunner's Primary Sight
GTIN	Global Trade Item Number

HB	Heavy Barrel
HEAT	High Explosive, Anti-tank
HIBCC	Health Industry Business Communications Council
IG	Inspector General
IOC	Initial Operating Capability
IUID	Item Unique Identification
LCAC	Landing Craft Air Cushioned
LTI	Limited Technical Inspection
MARCORSYSCOM	Marine Corps Systems Command
MBT	Main Battle Tank
MCPP-N	Marine Corps Prepositioning Program-Norway
MEU	Marine Expeditionary Unit
MEV	Military Equipment Valuation
MLG	Marine Logistics Group
MPF	Maritime Prepositioning Force
MPSRON	Maritime Preposition Squadron
MTVR	Medium Tactical Vehicle Replacement
NBC	Nuclear, Biological, and Chemical
Nd:YAG	Neodymium-doped Yttrium Aluminum Garnet
NSN	National Stock Number
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OIF	Operation Iraqi Freedom
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
OUSD (AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology, & Logistics
PEI	Principle End-item
PLRS	Position Location Reporting System
PM	Preventive Maintenance
PMA	President's Management Agenda
PMCS	Preventive Maintenance Checks and Services
PSA	Pressure-sensitive Adhesive
RADIAC	Radiological Warning Device
RCT	Regimental Combat Team
RIP	Reparable Issue Point
SFFAS	Statement of Federal Financial Accounting Standards
SMRC	Source Maintenance Recoverability Code

TACOM	Tank-automotive and Armaments Command
TAV	Total Asset Visibility
TI	Technical Instruction
TIGER	Total InteGrated Engine Revitalization
TIS	Thermal Imaging System
TYAD	Tobyhanna Army Depot
UID	Unique Identification
UII	Unique Item Identifier
UK	United Kingdom
USMC	United States Marine Corps

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I. Introduction

A. Background

> While DoD reports show that the department currently owns about $67 billion of inventory, shortages of certain critical spare parts are adversely affecting equipment readiness and contributing to maintenance delays [….] Despite the shortages of parts, more than half of DoD's reported inventory—about $35 billion—exceeded current operating requirements. (GAO, 2005)

The Department of Defense (DoD) is perhaps the world's largest and most complex organization and has the preeminent responsibility of protecting the security and interests of the United States. An enormous secondary inventory[1] valued at approximately $67 billion would suggest that the DoD is sufficiently—if not exceedingly—prepared to respond to any threats to national sovereignty. However, each of the military services continues to suffer from significant shortages of critical spare parts such as tires, tank tracks, and helicopter spare parts, even when $35 billion[2] of inventory exceeds current operating requirements.

1. Federal Government High-risk Programs

In 1990, the General Accounting Office (later changed to the Government Accountability Office in 2004, or GAO) initiated a program to identify high-risk areas within the federal government that possess a greater susceptibility to fraud, waste, abuse, and mismanagement (GAO, 2000). A program or area that holds national significance and meets certain quantitative (i.e., more than $1 billion is at risk) and

[1] Secondary inventory includes reparable components, subsystems, and assemblies other than major end-items (e.g., ships, tanks and aircraft). It also includes consumable items, bulk items, subsistence, and expendable end-items, including clothing and other personal gear (GAO, 2007b).

[2] This estimate does not include storage or holding costs, which can be formidable. For example, the GAO (2007b) found that it costs the Air Force—the largest contributor to the DoD's total on-hand inventory on the basis of value (39% or $28.9 billion)—as much as $30 billion annually to store unneeded inventory.

qualitative (i.e., significantly reduced effectiveness and efficiency) criteria will merit a high-risk designation.

The DoD's inventory management, later expanded in 2003 to include DoD supply chain management,[3] is not only one of the fourteen charter designations on the first high-risk list issued in 1993, it has also been on every biennial update since the high-risk program commenced. GAO audits have consistently determined that inventory levels are too high and that the supply system does not adequately support the needs of the warfighter—partly because the DoD lacks visibility and control over its supplies and spare parts (GAO, 2005). With mandatory entitlement programs threatening to consume even more scarce budgetary resources in the future,[4] discretionary defense spending cannot continue to accommodate inefficient inventory management practices that not only result in billions of dollars of unnecessary inventory but also produce deficiencies in spare parts that directly affect readiness.

2. Causes for Excessive Inventory

There are myriad reasons—some that are beyond the scope of this report—why inventory levels may be excessively high, yet operations suffer from the absence of critical spare parts. These include, but are not limited to the following reasons.

a. Budget Execution

A culture exists within the DoD that reinforces 100% execution of Operations and Maintenance (O&M) appropriations; any variation from that target is perceived

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[3] Hugos (2006) defines supply chain management as "the coordination of production, inventory, location, and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served" (p. 4).

[4] Spending for mandatory entitlement programs (e.g., Social Security, Medicare and Medicaid) accounted for 53% of all federal outlays in 2006—a 27% increase over the course of 20 years that easily outpaced debt service and forced discretionary spending to decrease by 29% to accommodate the growth (GAO, 2007a).

as a poor management of resources. Furthermore, since O&M appropriations can only be obligated during the year issued, DoD budget managers never risk having excess money available—otherwise funding levels in subsequent years may be jeopardized. Accordingly, when there are excess funds prior to the end of the Fiscal Year (FY), the priority for subordinate units is shifted from purchasing what is necessary to exhausting appropriations by any means before expiration. Thus, when the focus is no longer on requirements, excess inventory accumulates.

b. Acquiring Spare Parts to Improve Readiness

The emphasis to exclusively acquire spare parts to improve readiness without also examining repair cycle-times and component reliability may result in inventory exceeding operational requirements. Apte and Kang (2006) conclude that spare parts exhibit a diminishing marginal utility, so that when a certain threshold is reached, any additional spare parts purchased will not improve readiness. In fact, the introduction of unnecessary spare parts into the maintenance cycle may create a greater burden for the depots, thereby increasing repair cycle-times and leading to further shortages of critical parts.

c. Inventory Visibility and Control

Notwithstanding numerous other causes of excessive inventory, our position is that department-wide visibility and control over inventory is the core problem for the DoD. If inventory data is not accurate, wholly transparent, and timely, then the DoD will continue to make wasteful investments in unnecessary stock. Since demand for military inventory is often variable because of the unpredictable nature of operations, accuracy and transparency throughout the supply chain is even more vital for efficient readiness. Otherwise, tactical units will order excessive quantities to compensate for any perceived uncertainties, lack of confidence in the supply system, or loss of visibility of assets in the pipeline. This behavioral overreaction will

produce more inventories through a bullwhip effect,[5] in which oscillating demand is amplified throughout the supply chain.

3. Total Asset Visibility

Inventory visibility has been a concern for the DoD for decades, given that Total Asset Visibility (TAV) has been pursued since the 1970s. The DoD defines TAV as "the ability to provide timely and accurate information on the location, movement, status, and identity of units, personnel, equipment, and supplies and having the ability to act on that information" (GAO, 2004b, p. 1). With successive target completion dates of 1980, 1995, 2004, and presently 2010, TAV has proven to be an elusive goal. Accordingly, the GAO is not certain that the DoD will meet the 2010 goal (GAO, 2004b).

While TAV may not be achieved by 2010, the Unique Identification (UID) program appears to be the solution for arguably the most troublesome, yet critical, portion of TAV: reliably identifying and capturing equipment data in a central automated registry that transcends service boundaries to provide information on the location and condition of assets.

4. Unique Identification

Essentially, the UID program (or more specifically, Item Unique Identification (IUID) as it applies to inventory items) mandates the use of a Unique Item Identifier (UII), which is comparable to a social security number that globally and uniquely distinguishes all DoD tangible inventory items (from acquisition to disposal) that meet certain cost and management criteria. Not only will IUID enhance visibility, it will also improve lifecycle item management since all UIIs will contain historical

[5] The bullwhip effect is an examination of supply-chain dynamics in which small order variability at the customer level amplifies the orders for upstream supply-chain participants, such as wholesalers and manufacturers. The "whip lash" detrimentally affects the entire supply chain since the amplification of even minor swings in demand requires each upstream participant to progressively increase the level of inventory to maintain established service levels (Bagchi & Paik, 2007).

engineering and logistics support data. Furthermore, the top-down design of the centralized information repository (IUID Registry) is perhaps the greatest benefit of the IUID vision, as it eliminates the interoperability barriers created by the proliferation of parochial inventory systems throughout the DoD. Although each DoD unit may still maintain a parallel inventory management database to capture, modify and query local IUID data, all activities will be required to regularly interface with the centralized registry.

5. Department of Defense IUID Mandate

Theoretically, IUID has such a great potential to revolutionize inventory management practices and to produce substantial cost savings that the DoD has directed department-wide compliance. The first stage of compliance—issued by the Office of the Under Secretary of Defense (Acquisition, Technology and Logistics) (OUSD(AT&L)) on July 29, 2003—required IUID for all new equipment and material delivered in accordance with contract solicitations issued on or after January 1, 2004 (OUSD(AT&L), 2005). A subsequent policy update required the DoD's organic depots to begin IUID marking by January 1, 2004, on all tangible assets manufactured (OUSD(AT&L), 2005). The last major policy update, issued December 23, 2004, required IUID markings on all significant operational or in-use (legacy) items currently in the DoD's inventory to be completed by December 31, 2010 (OUSD(AT&L), 2005). While the depots may represent approximately 80% of the IUID solution (Durant, 2007) and since the majority of legacy marking will occur in conjunction with depot-level maintenance, Program Managers are ultimately responsible for ensuring IUID compliance over the legacy items for which they have cognizance (OUSD(AT&L), 2005).

B. Purpose

The purpose of this research is to propose an effective IUID implementation strategy for the legacy items on the Principle End-items (PEI)[6] in the US Marine Corps M1A1 Abrams tank community. Our recommendation presents the most appropriate path to achieve compliance while considering operational tempo, readiness, cost and feasibility. The difficulties that the tank community will face in meeting the IUID requirements are representative of the problems that all DoD activities may encounter. Therefore, this project may also serve as a model for other IUID implementation efforts.

C. Methodology

The methodology applied in this research project consists of the following:

1. Conduct a thorough review of IUID technology.
2. Conduct familiarization of the USMC M1A1 tank community.
3. Review current IUID mandates and implementation efforts in the Department of Defense.
4. Examine the progress of IUID implementation in the USMC M1A1 tank community.
5. Conduct a site visit to Marine Corps Logistics Base Albany, Georgia, and Anniston Army Depot (ANAD) Anniston, Alabama.
6. Observe and analyze current IUID applications and processes being implemented.
7. Gather cost data from pilot programs and IUID programs being implemented.
8. Build an effective IUID implementation plan that considers unit operational tempos, readiness objectives, cost and feasibility.
9. Prepare a summary and make recommendations.

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[6] End-items and replacement assemblies of such importance that management techniques require centralized individual item management throughout the supply system, to include depot level, base level, and items in the hands of using units ("Principle End Item," 2008).

II. Item Unique Identification

A. Introduction

Item unique identification enables the DoD to differentiate an item[7] from all other like items in an inventory and provides the source data to accomplish improved performance-based logistics services, capture accurate and reliable data on items, improve item lifecycle management, and track items for financial accountability purposes (OUSD (AT&L), 2006a). This chapter explores the origins of IUID in addition to examining the history and application of the program.

B. *Chief Financial Officers Act of 1990*

In 1990, the *Chief Financial Officers* (*CFO*) *Act* was enacted by the 101st Congress and signed into law by President George H. W. Bush. The Act called for sweeping financial reform in the federal government, where weaknesses in financial management oversight were leading to an unwarranted loss of public funds. For example, an examination of federal programs in 1989 by the GAO and the Office of Management and Budget (OMB) identified financial inconsistencies that could potentially create liabilities amounting to hundreds of billions of dollars (Jones & McCaffery, 1992). Additionally, the insolvency of more than 1,000 savings and loans associations in what Harvard economist John Kenneth Galbraith (1992) described as "the largest and costliest venture in public misfeasance, malfeasance and larceny of all time," (p. 61) which cost each American citizen nearly $2,000, represents the type of problems the *CFO Act* intended to prevent.

1. Financial Statements

Besides other requirements—including the establishment of 24 Chief Financial Officers responsible for all financial management functions within the

[7] A single hardware article or a single unit created by combining subassemblies, components, or parts.

federal government's departments and agencies—the *CFO Act* statutorily requires the federal government to prepare comprehensive financial statements to be submitted annually to the OMB. The financial statements must be able to withstand the rigors of an audit by the Inspector General (IG) of the preparing agency or by an external auditor determined by the IG (Sylvester, 2004). These audits reside in the final phase of the federal budget execution process. Charles A. Bowsher—former Comptroller General of the United States—testified before Congress that financial statement audits hold agencies accountable for their operations by ensuring that "accounting transactions, accounting systems, financial statements and financial reporting to [the] Treasury, OMB, the Public, and the Congress are properly linked" (Jones & McCaffery, 2001, p. 348).

a. Clean Audit

Each of the federal government's 24 departments and agencies must annually achieve an "unqualified opinion" or "clean audit" to be in compliance with the *CFO Act*. The clean-audit opinion is the highest opinion an independent auditor can issue as it certifies that the financial statement has been prepared in accordance with Generally Accepted Accounting Principles (GAAP) and accurately represents the financial position of the department or agency. In 2002, President George W. Bush recognized the value of a clean audit when he stated in the *President's Management Agenda* (*PMA*), "In the long term, there are few items more urgent than ensuring that the federal government is well run" (p. 1), and "a clean financial audit is a basic prescription for any well-managed organization" (p. 20).

b. Balance Sheet

A considerable portion of the financial statement is the balance sheet, which provides a snapshot of an organization's assets and liabilities at the close of the reporting period. The General, Property, Plant, and Equipment (GPP&E)—the largest asset line item for the DoD—includes the value of real property (e.g., land, buildings, structures) and personal property (Sylvester, 2004). Sylvester (2004)

defines DoD personal property as items that are not for sale or consumed during normal operations and includes support equipment, plant equipment, and vehicles.

c. Military Equipment

On May 8, 2003, the Federal Accounting Standards Advisory Board (FASAB)—the entity responsible for promulgating accounting standards for the United States Government—adopted "*Statement of Federal Financial Accounting Standards* (*SFFAS*) *23*," which categorized all military equipment (e.g., aircraft, ships, tanks) as personal property (FASAB, 2003). This monumental change meant that all military equipment that equals or exceeds the DoD-capitalization threshold of $100,000 for both the General and Working Capital funds must be valued, depreciated, and reported as GPP&E assets; in other words, the DoD could not "expense" the acquisition costs of military equipment as it had historically done (FASAB, 2003). *Accounting* for GPP&E as noted above is not the same as *accountability*. Accountability refers to protecting the GPP&E from loss, destruction, or improper use and preserving it in an acceptable and operable condition (deBardelaben, 2000).

2. The DoD and the *CFO Act*

For FY 2007, the DoD was not one of the 19 CFO activities that achieved a clean-audit opinion on its financial statement (Peters, 2008). Perhaps one of the most significant and challenging tasks in strengthening the accuracy of financial reporting data and achieving *CFO Act* compliance for the DoD is the ability to account properly for its substantial inventory. As the GAO (2004a) noted, "[the] DoD does not have the ability to produce accurate, reliable, and timely information to make sound decisions and to accurately report on its billions of dollars of inventory and other assets" (p. 1).

Given its unique structure and complex mission as one of the largest organizations in the world, it is not surprising that the DoD is undoubtedly several, if not many years away from *CFO Act* compliance. The DoD is an organization that

relies extensively on an enormous inventory spread across the globe; with 500 bases in over 137 countries and territories throughout the world (Jones & McCaffery, 2008), capturing accurate and reliable cost data of complex military systems beyond rudimentary estimates for inclusion on financial statements is an overwhelming task for the DoD. Furthermore, the uncertainty associated with the wars in Iraq and Afghanistan have complicated defense financial management through (among other reasons) weaknesses in inventory management. For example, during the initial stages of Operation Iraqi Freedom (OIF), there was a $1.2 billion discrepancy between material shipped and material received in the Iraqi theater (GAO, 2004b). However, for an organization that is tailored for the business of war, the DoD cannot afford to be paralyzed by ineffective inventory management that results in unreliable financial data. Former Secretary of Defense Donald Rumsfeld estimated that, once proper financial management is achieved, the DoD could potentially save up to $18 billion annually[8] (Jones & McCaffery, 2008).

3. Military Equipment Valuation

On the way to *CFO Act* compliance and in response to *SFFAS 23*, the DoD conceived the Military Equipment Valuation (MEV) initiative to "value, capitalize, depreciate, properly account for, and report military equipment on financial statements" (Sylvester, 2006, p. 33). The first step of this arduous process was to establish the initial value of every significant piece of military equipment in the DoD's arsenal. In the past, all military equipment was simply expensed when it was acquired; this policy change resulted in three years of computations to arrive at a net book value of approximately $300 billion for 1,100 individual weapon programs (Sylvester, 2006). In the future, the IUID program will be the primary catalyst to achieve MEV since all uniquely identified components will be directly linked to specific cost data, source documents and individual depreciation schedules. This will

[8] Other estimates for annual savings accrued from proper financial management are as much as $30 billion (Jones & McCaffery, 2008).

support the valuation granularity required by the FASAB, enable prompt balance-sheet reconciliations that contain accurate inventory appraisals, and provide reliable information for senior leadership and Congress to make informed decisions regarding appropriations.

Implementing IUID throughout the DoD will not be simple by any measure, but once accomplished, it will put the DoD one colossal step closer to achieving the elusive clean-audit opinion, which, when achieved, will confirm to the American taxpayer that the DoD is a trustworthy steward of assets.

C. IUID History and Background

The OUSD(AT&L) established policy that stated IUID was a mandatory requirement for all DoD contract solicitations issued on or after January 1, 2004 (OUSD (AT&L), 2003). An update to the policy was published in late 2004, requiring IUID marking on all existing legacy items which met the criteria (OUSD (AT&L), 2006a).

The original IUID policy (2003) established specific criteria to determine which items were to be marked. The following parameters establish the criteria:

- Acquisition cost of the item is or exceeds $5,000.
- An item has a value of less than $5,000 and is either serially managed, mission essential or controlled inventory equipment or a reparable.
- The Program Manager determines that an item's component with a value of less than $5,000 requires IUID.
- Any DoD serially managed subassembly, component or part embedded within an item, and the item itself, regardless of value.

Figure 1 contains a decision tree based on the aforementioned criteria for deciding which DoD items should be uniquely identified. The Program Manager is responsible for determining which items must be identified with IUID.

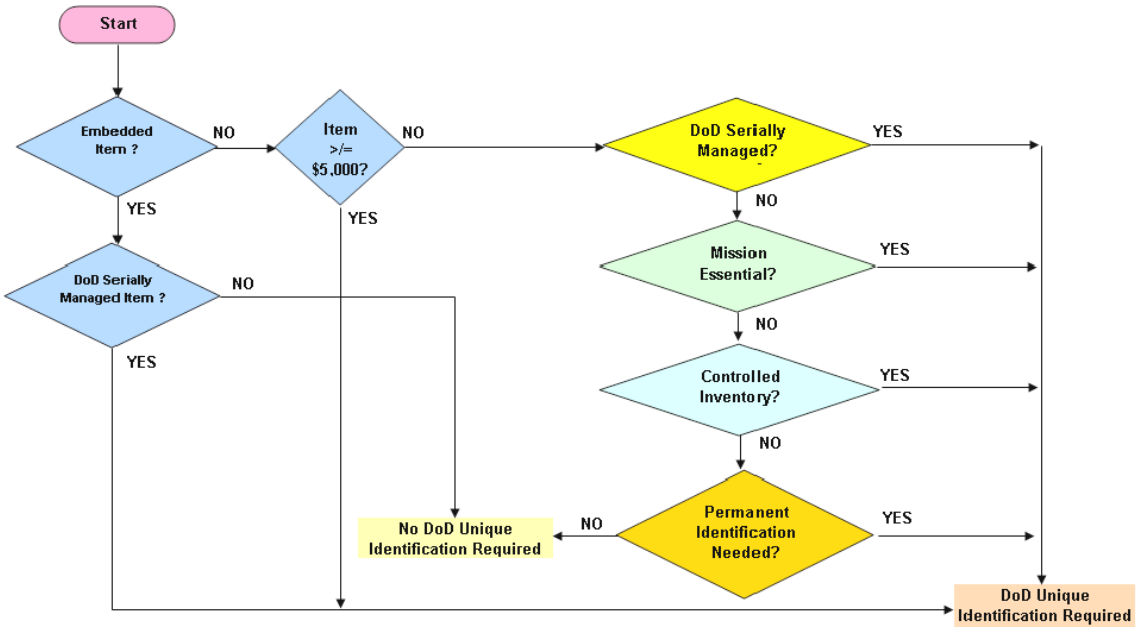

Figure 1. Decision Tree to Identify Items Requiring IUID
(OUSD (AT&L), 2006a, p 13)

For items not meeting IUID criteria, there is no need to distinguish between duplicate items of a product, so commercial marks can be used. A few examples of DoD-approved commercial marks are the EAN.UCC Global Trade Item Number (GTIN), ANSI T1.220 COMMON LANGUAGE Equipment Identification (CLEI) for telecommunications equipment, and the Health Industry Business Communications Council (HIBCC) code for non-pharmaceutical health-care products (OUSD (AT&L), 2006a).

Once an item meets the criteria for IUID, it is assigned a UII. A UII is a set of data elements that are globally unique and unambiguous. There are two constructs of UII. Construct 1 is used for items that are serialized within the enterprise[9] identifier, and the UII data set captures the data elements of enterprise identifier and a unique serial number. Construct 2 is used for items that are serialized within the

[9] The entity (e.g., manufacturer or vendor) responsible for assigning unique item identifiers to items (OUSD [AT&L], 2006a)

part, lot or batch number within the enterprise identifier, and the UII data set includes the data elements of enterprise identifier, the original part, lot or batch number, and the serial number (OUSD (AT&L), 2006b). The UII is part of the IUID mark.

D. Department of Defense Progress

The IUID program office for the DoD estimates that out of the approximately 100 million components that meet the criteria for marking, 4% have been marked thus far, with the majority of the markings resulting from new acquisitions. With the exception of the Air Force, the services have not yet fully funded IUID implementation—meaning it will be nearly impossible for the DoD to achieve legacy inventory marking compliance by December 2010. Mr. Charlie Lord, a staff analyst at the IUID program office, posits that the DoD components are not achieving significant progress because there is not sufficient command emphasis; there is a ubiquitous competition for resources, and there is a lack of understanding of the intent of IUID and the corresponding benefits.

The researchers' site visits to the Marine Corps Logistics Command's Maintenance Center at Albany, Georgia, and ANAD perhaps confirm Mr. Lord's position; the authors of this report encountered only a few select individuals who understood the scope of the IUID program and even fewer who saw any long-term benefits to implementation. Although both depots have achieved minimal IUID Initial Operating Capability (IOC),[10] including the ability to interface with the IUID Registry, the marking processes are time consuming and labor intensive. For example, at the Marine Corps depot, it takes no less than approximately 15 minutes to achieve compliance for one item, including producing an IUID-compliant aluminum label using a Carbon Dioxide (CO_2) laser.

[10] Initial Operating Capability (IOC), as it applies to UID, is a sub-set of Full Operating Capability (FOC) and represents the point at which the depot is capable of performing minimum essential UID tasks on a limited population of tangible inventory items (OUSD (AT&L), 2005).

At ANAD, the only maintenance depot for the USMC M1A1 Main Battle Tank (MBT), no marking has taken place to date on the tank—with the exception of the Honeywell AGT-1500 engines arriving from the Original Equipment Manufacturer (OEM) under the Army's Total InteGrated Engine Revitalization (TIGER)[11] program. However, the IUID steel data plate representing the engine is fastened by conventional screws to a metal shaft that can be easily separated from the item (engine) it is intended to identify.

E. IUID Marking

Items in the DoD inventory that meet the IUID criteria are required to be marked with a two-dimensional (2D) data matrix symbol, shown in Figure 2.

Figure 2. Example of 2D Data Matrix
(OUSD (AT&L), 2006a, p. 33)

The square contains light and dark square modules and can contain up to 2,000 characters. The symbol is square or rectangular and can measure from 0.001 inch per side to 14 inches per side. A 2D imaging device is necessary to scan the symbol. A regular bar code scanner will not read the matrix. The data matrix can be applied using a wide variety of printing and marking technologies (OUSD (AT&L), 2006a). The 2D data matrix contains the UII construct data for each item. According

[11] The Army introduced the TIGER program in 2006 with the intent of revamping the M1 engines in an effort to double the meantime between depot repairs. The US Army Tank-Automotive and Armaments Command (TACOM) estimates that the Honeywell AGT-1500 gas turbine engine accounts for approximately 42% of overall M1 support costs (Colucci, 2006).

to UID 101 (2006), there are many advantages to using a 2D data matrix symbol instead of a bar code.

- The ability to hold 100 times the data in the same space,
- The ability to be read by the scanner omni-directionally,
- The ability to be accurately read with up to 20% damage (Johnson, 2004), and
- Scalability to fit within available marking space.

The DoD standard practice identification marking of US military property (*MIL-STD-130N*) is the sole IUID marking authority. There is a four-step process for marking IUID items: create the 2D data matrix, verify the information on the matrix is within standards, validate that the data constructed is accurate for future tracking, and affix the matrix to the item.

The 2D data matrix can be created by using a variety of software programs contracted by the DoD. Once the information is typed in the computer, the symbol is created. Program Managers are responsible for determining the method of marking the DoD equipment they are responsible for. Equipment can be marked with data plates, adhesive labels, or Direct Part Marking (DPM) by laser etching. Currently, the Marine Corps Maintenance Depot at Albany, Georgia, is using data plates and adhesive labels on items in the Marine Corps inventory. Similarly, ANAD is using the same materials for marking Army equipment. The data plates are created using a laser engraver linked to the computer. As stated above, data plates at the Albany Depot and ANAD are created in an average time of 15 minutes.

The next step is to verify that the information on the matrix is in compliance with *MIL-STD-130N* and the Program Manager's Statement of Work requirements. The data on the matrix can be verified with a device called a verifier.

Once verification is complete, the data constructed on the matrix needs to be validated for future tracking. By using the verifier to read the data on the matrix,

Program Managers can ensure a label's accuracy. The last step is to affix the data plate or adhesive label to the item. The Program Manager determines where each part is marked and makes sure the placement is in accordance with *MIL-STD-130N*.

1. Data Plates

Currently, IUID data plate marking is the most used marking method in the Marine Corps. According to the Zebra Corporation's black and white paper (2008), data plates can be created at the maintenance depot facilities or ordered from a supplier. If the latter method of procurement is used, Program Managers must have tight control processes in place to ensure accurate UII construction on the plate. Two advantages to using data plates are that they can come in a variety of plastics and metals, which forms provide durability in harsh operating conditions, and they can be affixed to the item with high-strength adhesives, rivets, screws, or other fasteners. The Marine Corps is using the data plate marking technology because it has the equipment from the Marine Corps pilot program and because most marked items are the PEIs. However, there are some limitations to data plate marking, as the Zebra black and white paper (2008) describes below:

- The equipment to create data plate markings is fairly expensive compared to other marking methods.
- Time, labor, and expenses are added when fasteners are used to apply data plates.
- Data plates cost approximately 10 times more than label markings.
- Rigid data plates cannot be used to mark items with odd-shaped surfaces or those that are uneven.[12]

The data plate method of marking has advantages and disadvantages, but because of limited resources and equipment, it remains one of the Marine Corps' primary IUID marking methods. As the Marine Corps and other services expand their

[12] Anodized aluminum foil data plates are flexible enough to be applied to uneven surfaces.

IUID capabilities to the component level, the need for alternate marking methods will arise.

2. Label Printing

Label printing is currently being used by the Marine Corps and Army for marking small IUID items. The Zebra black and white paper (2008) states that label printers are all most DoD agencies will need to satisfy marking requirements for items on which a permanent adhesive label can be affixed. Thermal transfer printers[13] will meet IUID requirements because they provide exceptional print quality for 2D matrix symbols, especially for small items. The main advantage for label printing is that it is the least expensive way to mark IUID items. Other advantages of label printing include the many styles and sizes of printers, high-volume print capability, minimal software updates required, and user-friendliness. According to the Zebra Corporation (2008), the key limitations for label printing are that the labels cannot be less than 1 inch wide, and the labels will not withstand high temperatures and other extreme conditions. Under these conditions, the item will require a special data plate or DPM.

3. Direct Part Marking

The Marine Corps and Army are not currently using the Direct Part Marking (DPM) method. The Zebra black and white paper (2008) explains that this marking process stamps or etches a symbol directly on the item. The type of marking depends on the composition of the item and its structural tolerances. According to Davis et al. (2008), three processes currently meet the *MIL-STD-130N* criteria for marking: laser, dot peen, and electrolytic etching. Advantages of using laser over the other two DPM methods include no hazardous waste, no consumables, ease of use, high marking speeds, and the ability to precisely and consistently control

[13] Printers that work using a print head to apply heat to a ribbon, which melts the image onto the label material and creates a long-lasting image (Zebra, 2008).

parameters. The Zebra black and white paper (2008) lists general advantages of DPM:

- The durability and space efficiency of the data symbol that can be used on items on which data plates and labels cannot be used,
- The only marking alternative for certain items subject to extreme environmental conditions, and
- The symbol becomes part of the item for the lifetime of the item.

Although there are some great benefits to DPM, there are also disadvantages. The Zebra black and white paper (2008) states the limitations of dot peen and electrolytic etching DPM as extremely slow marking processes; in addition, waste can be an expensive problem, and if DPM is applied incorrectly, the item itself is wasted—not an inexpensive label or data plate. Since DPM on a legacy item can introduce fatigue effects throughout the lifetime of the item, this marking method must be carefully considered because the effects of a laser-generated mark were not accounted for when the part was originally manufactured (Davis et al., 2008). An example of a laser-generated crack is shown in Figure 3.

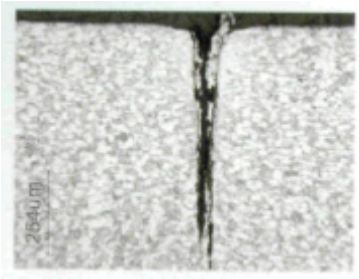

Figure 3. Example of Laser-generated Crack
(Davis et al., 2008, p. 27)

Direct part marking can be an effective means of marking IUID items or can be very costly if parts or items are marked incorrectly.

F. IUID and the Configuration Control Process

The configuration control process is employed by contractors and the DoD to prepare, justify, evaluate, coordinate, resolve, and implement proposed engineering or configuration changes. The primary objective of configuration control is to establish and maintain a systematic change-management process that regulates lifecycle costs (OUSD (AT&L), 2001). Once the first configuration document is approved and baselined for a particular component or system, an Engineering Change Proposal (ECP) must be submitted to support any recommended changes that may correct problems or improve—among other things—operational readiness, supportability and safety. Unlike the early phases of program development, the configuration control process is an especially regimented and formal process during sustainment because of the complexity involved with changing a deployed weapon system.

The two categories of ECPs are Class I and II. The Configuration Management Guidance publication lists the general criterion for a Class I ECP as any change that "affects any physical or functional requirement in approved functional or allocated configuration documentation" (OUSD (AT&L), 2001, pp. 6-16) whereas Class II essentially covers any other change proposal. Class I ECPs must be approved or disapproved by a Configuration Control Board (CCB) whose membership is—at a minimum—comprised of the functional or subject-matter experts from the cognizant DoD organization. For Class II disposition, unless otherwise specified by contract, the government administrative contracting officer or plant representative serves as the adjudicator.

Unique identification will demand an inordinate amount of attention from the configuration control process because every part that is identified to be marked will require a thorough engineering analysis and positive disposition prior to application. The IUID tag selection and method of applying must be carefully analyzed to determine if the tag will change the form, fit, or function of a component. It can be generally assumed that an intrusive method of application (e.g., DPM, drilling holes

to affixed data plates) will require no less than a Class I ECP, thereby increasing costs when compared to affixing a data plate with a high-strength bonding agent.

G. IUID Registry

The IUID Registry is the DoD's central repository for IUID information and provides information on what the item is, how and when it was acquired, the purchase value of the item, current location of the item, and how the item is marked. As DoD information systems evolve, the registry will support full lifecycle visibility for tangible items, integrating financial, maintenance, and accountability systems (IUID, 2006). The Program Manager is responsible for ensuring marked legacy item information is transferred to the registry. One of the ways a Program Manager can input information on an item before the item is marked is by using a virtual UII.

1. Virtual Unique Item Identifiers

Virtual UIIs enable the input of a UII and its associated pedigree data in the IUID Registry, while postponing the physical marking of the item with a 2D data matrix until a more advantageous time. Legacy items are the only items permitted to have a virtual UII assigned to them, and they must have been operational prior to the IUID policy implementation. When the item is physically marked with the 2D data matrix, the mark should be updated to reflect the change from a virtual UII to a compliant UII (OUSD (AT&L), 2006b).

2. Marine Corps IUID Repository

The Marine Corps is using the IUID Registry and a separate IUID temporary data storage, which is the Marine Corps' repository for IUID data until Global Combat Support System-Marine Corps (GCSS-MC) comes online. GCSS-MC is a portfolio of systems that support logistics elements of command and control, joint logistics interoperability, and secure access to and visibility of logistics data. The databases will be populated as legacy items are given UIIs (Marine Corps, 2008). It is important that any systems in use other than the IUID Registry are pull systems to the registry, as to not modify any data in the registry.

3. Automated Identification Technology

The DoD established a logistics Automated Identification Technology (AIT) concept of operations in 1997 to create a more efficient means to tracks assets. According to Roberts (2003), AIT is a suite of technologies that makes possible the automatic capture and transmission of source data, which enhances the ability to identify, track, document, and control material and maintenance processes. Automated identification technology uses a variety of read/write data storage technologies that include bar codes, magnetic strips, integrated circuit cards, and optimal memory cards that capture an item's identification information. The benefits of the technology are increased speed and accuracy in automating data collection, data transfer, and the effort involved in error correction. Automated identification technology hardware and software are required to create storage devices, read the information stored on them, and integrate the stored data with other logistics data (Roberts, 2003). The need for accurate information in the established logistics databases is critical if Program Managers are to mark items with IUID, as they will extract a majority of the information included on the 2D data matrix from the databases.

H. IUID Benefits

Currently, it is difficult to see any benefit of implementing IUID because it is in its infant stages. The implementation seems more of a burden than a beneficial tool. The true benefits will be seen as the implementation continues, as the IUID Registry becomes populated with more items, as technology is in place at the user level, and as information systems become more widely available. Some benefits of IUID include more efficient supply chains, the potential for a paperless system, and improved speed and accuracy of data transfer.

1. Supply Chain

In the DoD, a supplier may take the form of a vendor, maintenance depot, or unit supply section. Item unique identification will decrease the cycle-time of an item

from the time it was acquisitioned to the time it is delivered to the customer. Maintenance cycle-time will decrease because maintenance facilities will be able to maintain better accountability of items requiring maintenance from the time they leave the customer for repair to the time they are delivered back to the customer. The last mile barrier[14] will be easier to overcome with the asset visibility that IUID will provide. The DoD supply chain needs IUID to improve its processes as the most complex organization in the world.

2. Enabler to a Paperless System

Once fully implemented, IUID will enable a paperless accountability system. The DoD spends countless hours manually inputting data into databases and log books at every level of operation. The data that IUID will encompass will allow information systems to account for the majority of transactions. These transactions can be acquisitions of new weapon systems, lifecycle management transactions, and maintenance transactions.

3. Speed and Accuracy of Data Transfer

Item unique identification will generate a greater speed and accuracy of data transferred from one system to another. There will be a significant reduction in the potential for human error when inputting transactions into the systems. The accuracy will allow the DoD to keep greater accountability of its assets. There will be a significant reduction in man hours for inputting data into computer systems and logbooks because of IUID. The increased speed of data transfer will allow for almost real-time asset tracking, which is one of the goals of the DoD. The enhanced speed and accuracy of data transfer from IUID is going to make supply and logistics operations more transparent and provide a more accurate snapshot of the current DoD asset posture.

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[14] The final stage in the supply chain, linking the providers of goods and services to their customers.

III. USMC M1A1 Abrams Main Battle Tank

A. Introduction

To better understand the tank community, a history of how the United States military, in general, and how the Marine Corps, in particular, came to possess the M1 Abrams MBT must be addressed. This chapter begins with an overview of the initial development and procurement of the M1 tank and subsequent upgrades. A more specific history regarding the M1A1 variation and the acquisition of the M1A1 by the United States Marine Corps follows. Then, the current disposition of tanks in the Marine Corps is presented in order to familiarize the reader with the scope of this community's footprint. Finally, the role of Marine Corps armor is discussed in order to demonstrate the ongoing need and longevity of this community, thereby justifying the effort and cost to incorporate it into the DoD IUID program.

B. History of M1 Series Development and Acquisition

1. From Concept to Prototype

The precursor program that resulted in the M1 MBT began in December 1971. The program was initiated by the US Army, which desired a replacement for their aging M60 fleet. In February 1972, the Army organized a task force comprised of users, trainers and developers to create the concept for the new battle tank (Jane's, 2008). Their report was published in August 1972. Almost one year later, two bidders were awarded prime contracts to develop prototypes of the new tank. The Army accepted the first prototype vehicles from both US contractors in February 1976 and conducted operational and engineering testing through April of that same year (2008).

Chrysler Corporation ultimately won the ensuing competition and was selected for full-scale development and production. Chrysler, however, sold its tank-building subsidiary (Chrysler Defense Incorporated) to General Dynamics in March 1982 (Jane's, 2008).

2. Building the M1 Series of Tanks

The Lima Army Tank Plant in Lima, Ohio, and the Detroit Arsenal Tank Plant have built all the original M1 tanks and their variations from the ground up. The Detroit Arsenal Tank Plant closed at the end of 1996 because production of new tanks ceased. Currently, the Lima Plant upgrades the older M1s to the M1A2 configuration, but there are other facilities capable of upgrading, overhauling, and rebuilding the various versions of the M1 in service with the Army and Marine Corps. The first production M1 MBT rolled off the line in February 1980. The original intention was to procure 3,312 M1s, but in 1978, this figure was increased to 7,058 to be delivered by the end of FY88; in 1984, the figure was further increased to 7,467 (Jane's, 2008). Ultimately, only 2,374 M1s were produced. The last M1 was produced in February 1985 when production switched to the Improved M1, which continued until May 1986. The Improved M1 was followed by the M1A1.

3. The M1A1 Main Battle Tank

The M1A1 actually began production in August 1985, even though the M1 Improved was still being built. The M1A1 marked a large step forward in the ability of the series to survive on the battlefield as well as to move and shoot—two of the hallmarks of a mechanized asset. The M1A1 included the upgraded armor of the Improved M1, which was further upgraded in 1988 to steel-encased Depleted Uranium (DU) armor, which has two-and-a-half times the density of steel. The latest upgrade of the M1 also incorporated the Rheinmetall 120 mm M256 smoothbore gun and an integrated Nuclear, Biological, and Chemical (NBC) system. These improvements gave the M1A1 and crew significantly better battlefield survivability and greater killing power compared to the 105 mm cannon on previous M1 versions. Additionally, the mobility of the M1A1 was increased by improving the torsion bars and shock absorbers of the suspension system and modifications to the transmission, roadwheels and final drive (Jane's, 2008). Other cosmetic and functional upgrades were included that improved the overall fightability of the tank. However, because of the larger size of the 120 mm ammunition carried by the

M1A1, only 40 total rounds can now be stored on board. There are 34 in the turret bustle rack and 6 in a rear storage box located in the hull of the tank.

April 1993 marked the end of M1A1 MBT production—with a total of 4,796 vehicles being built at the Lima, Ohio, and Detroit, Michigan, Tank Plants (Jane's, 2008). Further information on the specifications and capabilities, as well as an in-depth description of the workings and systems on the M1A1 MBT, is located in Appendix A.

C. The M1A1 and the United States Marine Corps

In the late 1980s, the Marine Corps became increasingly concerned with the ability of its venerable fleet of M60A1 tanks to match up against the newest Soviet threats (e.g., T-72s and T-80s). An interim add-on reactive armor package was purchased, but with the Army converting completely to the M1 series, the Marine Corps recognized that logistic support for the M60 would fall solely on them. Thus, after struggling with the decision for years, the Marine Corps finally chose to adopt the M1A1.

1. The Marine Corps Gets the M1A1

Originally, the Marine Corps hoped to replace its fleet of 716 M60A1s with 490 M1A1s (Estes, 2000). They planned to cover the difference in numbers by switching from five tank platoons to four tank platoons and, thus, reducing their depot and prepositioned requirements. The Marine Corps received its first M1A1 in November 1990. At the time, the main differences between the Marine Corps tank and the one the Army was procuring were a Deep Water Fording Kit (DWFK), interface hardware to accept the Position Location Reporting System (PLRS) and additional tie-down points for stowage on board ship and transportation on Landing Crafts Air Cushioned (LCACs) of the US Navy (Jane's, 2008).

Ultimately, the initial procurement of M1A1s by the Marine Corps was pared down to 221. The original plan for fielding the M1A1 in the Marine Corps called for

training all of the Marine Corps' tank battalions on the first 16 tanks at Twenty-nine Palms, California, during 1991 and then completing the procurement in 1992 (Estes, 2000). Operations Desert Shield and Desert Storm would change that plan. The Marine Corps borrowed 60 M1A1s from the Army for the first Gulf War. There were also 16 Marine Corps M1A1 tanks delivered on an accelerated schedule that were used during the operation. The 2nd Tank Battalion and elements of the 4th Tank Battalion employed this total of 76 M1A1 tanks. All loaned tanks were returned to the Army after Desert Storm (FAS, 2000).

2. Overcoming Opposition from Within

Despite the impressive performance of the M1A1 in Operation Desert Storm, the USMC tank community faced stiff opposition from the major decision-makers in the Marine Corps. Many still did not believe that a heavily armored force had a place in the Marine Corps. Therefore, the acquisition of the congressionally approved M1A1s for the Marine Corps was delayed, killed and reborn several times in the years following the war. With only 221 of the original 490 requested, the USMC tank community was suffering a serious shortage. Finally, Congress authorized the transfer of 50 tanks from the Army in FY94 and another 132 in FY95 (Estes, 2000). Again opposition was met, but finally the Marine Corps decision-makers accepted the additional Army tanks in the spring and summer of 1995—bringing the Marine Corps total to 403. Many of the tanks transferred from the Army did not include the DU armor package, though. This posed somewhat of a problem as tank battalions shifted tanks around to ensure non-DU tanks did not deploy with the Marine Expeditionary Units (MEUs) or to OIF. This problem has since been rectified, and currently, all Marine Corps M1A1 tanks have DU armor. In early 2008, the Marine Corps began to take delivery of an additional 44 tanks from the Army, raising the total in the Marine Corps' inventory to 447 M1A1 Abrams MBTs.

3. Role of Marine Corps Armor

The role of tanks in the Marine Corps differs from that in the Army. In the Marine Corps, the tank is strictly combat support, while in the Army, the tank is often

the centerpiece of an operation. This is best exemplified by the fact that the Army fields entire divisions of tanks; yet, there are only two active-duty battalions and one reserve battalion in the Marine Corps. The reason for the difference is that the Marine Corps prides itself on being an expeditionary force. As mentioned, many Marines have fought not having any tank at all, let alone a large contingent. However, history has shown that when a tank is needed, nothing else will suffice. That is why it has been mandated that every MEU will include a platoon of tanks; even during stability and support operations in Iraq, the tank company attached to each Regimental Combat Team (RCT) is highly coveted.

4. Mission

The use of armor in the Marine Corps is best summed up by the mission statement of 2d Tank Battalion (2008), II Marine Expeditionary Force: "The mission of 2d Tank Battalion is to close with and destroy the enemy using armor-protected firepower, shock effect, and maneuver, and to provide precision direct fires against enemy armor, fighting vehicles, troops, and hardened positions."

The mission statements of the other two battalions are similar, with some clarification on supported units. The bottom line, though, is that the tank battalions are to use the strengths of their armored assets in order to support the infantry units in their parent commands. This requirement is not going to go away, and while the replacement for the M1A1 is being explored for both the Army and the Marine Corps, it is expected that the tank will serve well past 2020 and possibly as long as 2050.

5. Current Disposition

As of FY2008, the Marine Corps possessed 447 M1A1 tanks in its inventory, currently located at the sites outlined in Table 1. MPSRON represents the three Maritime Prepositioning Squadrons that the Marine Corps maintains. These are floating war stocks, and each one includes one battalion's worth of tanks—58. The two active duty battalions, 1st and 2nd, are currently maintaining 44 tanks each due to operational commitments for OIF. Each battalion is one company short, 14 tanks, of

its allowed inventory. The Enhanced Equipment Allowance Pool (EEAP) is maintained at the Marine Corps Air Ground Combat Center in Twenty-nine Palms, California. The three tank battalions use these tanks when they deploy to Twenty-nine Palms for a Combined Arms Exercise (CAX). Thirty-six tanks are located in Iraq in support of OIF. Both companies deployed to Iraq have four additional tanks that they fall in on, for a total of 18 each, in order to facilitate combat readiness. Additionally, there are 10 tanks staged in Iraq as Forward in Stores (FIS) to quickly replace combat losses. Finally, the 14 tanks that 1st and 2nd Tank Battalions are short and the 3 additional tanks recently transferred from the Army are being carried as Depot Maintenance Float Allowance (DMFA). These tanks are currently stored at ANAD.

Table 1. USMC M1A1 Disposition

	Allocated	On-hand
MPSRON 1	58	58
MPSRON 2	58	58
MPSRON 3	58	58
1st Tank Bn	58	44
2nd Tank Bn	58	44
4th Tank Bn	58	58
EEAP	22	22
OIF		36
FIS		10
DMFA		31

IV. M1A1 Abrams Main Battle Tank Maintenance

A. Role of the Program Manager

The Program Manager for the Marine Corps M1A1 Abrams MBT is responsible for providing research, development, acquisition and lifecycle support for the Marine Corps M1A1 Abrams MBT family of vehicles. The Program Management Office is split between Marine Corps Systems Command (MARCORSYSCOM) North in Quantico, Virginia, and MARCORSYSCOM South in Albany, Georgia. The office in the North is responsible for acquisitions and policies, while the office in the South concentrates on sustainment. Mr. Chris Duponte is the Senior Logistics Management Specialist and represents the Georgia office. He is responsible for ensuring that the USMC tanks maintain an acceptable level of readiness, above the DoD-mandated level of 85%. The Program Manager is also responsible for implementing IUID on all legacy tank reparables meeting the criteria. Mr. Duponte is the office representative taking the lead in IUID implementation. The majority of implementation takes place during routine maintenance,[15] so it is important for this project to address the tank maintenance processes the Marine Corps utilizes.

B. Types of Maintenance

There are two types of maintenance for the Marine Corps M1A1: preventive and corrective. According to the DoD *Dictionary of Military Terms* (2008), Preventive Maintenance (PM) is the care and servicing by personnel with the intent of maintaining equipment and facilities in satisfactory operating condition by carrying out inspections, detection, and correction of failures either before they occur or before they develop into major defects. When a component fails, maintenance is required to get the component back to an operational state, which is considered

[15] All action taken to keep materiel in a serviceable condition or to restore it to serviceability. It comprises inspection, testing, servicing, classification as to serviceability, repair, rebuilding, and reclamation ("Routine maintenance," 2008).

corrective maintenance. The conducting of proper PM is an important role of maintainers to keep the readiness of the tank community high and the required maintenance time low.

1. Maintenance Levels

The levels of maintenance can range from a 4-hour Limited Technical Inspection (LTI)—which is a routine inspections performed at the user level—to a 54-day complete rebuild of the tank completed at the depot. The Marine Corps uses four echelons of maintenance. The first echelon is the lowest, simplest level; the fourth echelon is the highest, most comprehensive level of maintenance. Different levels of maintenance units have authority to perform particular echelons of maintenance. It is possible for a level of maintenance to perform more than one echelon of maintenance.

a. User Level

The user level of maintenance in the Marine Corps is identified as the nearest level of maintenance to the ground forces. Each tank battalion in the Marine Corps has a built-in maintenance capability that is authorized to perform up to limited fourth-echelon maintenance and serves as the user level. Each tank battalion is comprised of four tank companies. The individual tank operators are authorized to conduct first-echelon maintenance, which occur daily, weekly, monthly and before, during and after operating Preventive Maintenance Checks and Services (PMCS), and which include inspections on the various parts of the tank hull and turret. Each company has a maintenance section that is authorized to perform up to second-echelon maintenance. There is also a battalion-level maintenance section responsible for up to third- and limited fourth-echelon maintenance that conducts semi-annual and annual services. Battalion maintenance is also responsible for conducting LTIs anytime the tank transfers owners. When tank reparables fail, maintenance personnel rely on the intermediate-level maintenance and supply capabilities to supply them with a rebuilt part. Once the part is received, the user level is responsible for replacing the part in the tank.

b. Intermediate Level

The Marine Logistics Group (MLG) performs the intermediate level of Marine Corps maintenance. Since the tank battalions perform the majority of the required maintenance, the MLG performs limited maintenance support on tank equipment. The primary dependence of MLG for the tank battalion is on its supply chain capabilities. The MLG supply and maintenance personnel operate the Reparable Issue Point (RIP). When a tank reparable fails, the part has to be delivered before the RIP issues a new part. The RIP will either repair the part or ship it to be repaired. The tank battalions rely heavily on the RIP supply chain capabilities to keep their readiness at a high level. When the tank meets the criteria for rebuild or requires maintenance beyond the user or intermediate levels, the tank will be sent to the depot level of maintenance.

c. Depot Level

All fourth-echelon maintenance that cannot be performed by the user or intermediate levels is performed at the depot level of maintenance. When the tanks are identified as candidates for rebuild, they are sent to the depot. The entire fleet of Marine Corps tanks cycles through fourth-echelon maintenance and the rebuild process at ANAD. In the past, the Marine Corps performed fourth-echelon maintenance and the rebuild process at individual maintenance depots in Barstow, California, and Albany, Georgia. The cost became too great, and a study proved that rebuilding tanks at ANAD could reduce costs. The current cost to rebuild a tank is approximately $1.3 million. To get the same level of service at Barstow or Albany, the cost would be approximately $2.5 million. The Marine Corps stopped utilizing their depots for tank maintenance and rebuild efforts in 2002. Since ANAD is equipped to provide maintenance and rebuild efforts on an Army fleet of approximately 10,000 tanks, the equipment economies of scale reduce the cost of maintenance and rebuilds. The number of tanks the Marine Corps rebuilds each year depends on the budget and the operational picture. Between FY 2005 and 2007, all tanks in the Marine Corps inventory were rebuilt at ANAD. The high operational tempo and congressional supplemental funding allowed this unusual act

to occur. The Marine Corps established Combat Vehicle Evacuation (CVE) criteria for tank rebuilds in the *Technical Instruction* (*TI*) *-08953A-14/9*, Enclosure (1) (1997, p. 2) as the following:

- When the hours of operation, months in active use, equivalent full charge rounds fired and miles traveled determine that the MIA1 will enter the rebuild cycle. The tank will be evacuated when it has operated for either 3,000 miles, 300 hours, or 750 equivalent full charge rounds fired.
- When an LTI shows that the M1A1 requires corrective repair beyond fourth-echelon capability, it will be reported as a candidate for evacuation.
- When an LTI shows that an M1A1 requires repair at fourth-echelon but will require extensive man-hours to bring it back to an operational condition, the tank will be considered as a candidate for evacuation.
- When an LTI shows that an M1A1 requires repair at fourth-echelon but would be an economic strain on the owning unit's operational budget, the vehicle will be considered as a candidate for evacuation.

The exceptions to this policy are based on the field commander's recommendations and discretion. The rebuild procedure takes an average of 54 days for a Marine Corps M1A1 tank. This number fluctuates because of variability in the supply chain and budgeting factors.

V. IUID Analysis and Implementation

A. Introduction

This chapter considers three possible methods of IUID implementation on the legacy components currently mounted on the Marine Corps' tank force. The desired outcome is to analyze a sufficient amount of information pertaining to each proposed course of action in order to guide decision-makers in determining the preferred implementation plan.

1. The first method utilizes the normal rebuild schedule for the USMC tank fleet.
2. The second method involves accelerating IUID implementation through a focused effort at the depot level.
3. The final method considers the use of special fielding teams to conduct IUID marking at the various tank locations.

Evaluation of each method is based on three criteria. The first is the length of time for the scenario to be completed, which is important because of the DoD's December 2010 completion mandate. The second criterion is the cost associated with each implementation plan. It is important to note the only costs to be considered in this project are the implementation costs. All amounts are in FY 2009 dollars unless otherwise stated. Feasibility, in terms of operational readiness, timing and costs, are the final criterion examined. We establish recommendations for the IUID implementation process by conducting an analysis of each scenario, based on the set criteria.

B. Considerations Common to Each Method

1. List of Parts Requiring IUID

One of our objectives in this project is to determine what legacy components on the USMC M1A1 MBT require IUID marking. To create a credible parts list, the following information was required for each part:

- Nomenclature,
- National Stock Number (NSN), which is a 13-digit stock number consisting of the 4-digit Federal Supply Classification code and the 9-digit National Item Identification ("National Stock Number," 2008),
- Source Maintenance Recoverability Code (SMRC), which indicates what levels of maintenance are qualified and have repair authority for the part, and
- Unit price of the part.

a. Parts that Require Marking

A list of every part on a USMC M1A1 MBT was obtained from the Program Manager's sustainment office in Albany, Georgia. The list contained all 14,153 reparable and consumable parts on an M1A1 tank. Additionally, the list possessed all of the appropriate information outlined above except the part nomenclature. Per DoD guidance, all parts with a value of $5,000 dollars or greater, or that are serially managed (i.e., all reparable parts) require IUID marking. The Program Manager has the ability to add or subtract parts from that guidance, but that possibility was not considered here.

b. Developing the List of Parts to Be Marked

To create the list of parts requiring IUID marking, the first step was for the researchers to separate all parts with a value of $5,000 or more from the original list of 14,153 parts to create a new list of parts requiring marking. Then, all of the reparable items were taken out and added to the new list. Additional research was then required to determine the nomenclature of each part on the new list. The new working list contained 1,024 parts with all of the relevant information, but further research was required.

With the help of Mr. John Jaaskelainen, the researchers conducted an analysis of each part to determine the applicability of IUID marking as well as how difficult it might be to reach and mark each part. Mr. Jaaskelainen is a General Dynamics representative contracted by the Marine Corps to be the field service representative at ANAD and is responsible for quality control on all USMC tanks that

are routed through the rebuild process at ANAD. Mr. Jaaskelainen was able to identify parts on the list that other commodity sections would be responsible for marking, and these parts were subsequently deleted from the working list. Examples of such parts are armory weapon systems, communications equipment, and maintenance equipment, such as tool kits and test sets. He also provided guidance on which parts were substitute or alternate NSNs,[16] and these parts were also deleted from the list. Through his expertise, he noted that some of the coded reparable parts were actually treated as consumable items. Therefore, if they did not meet the dollar threshold, they were removed from the working list. The final working list of 775 items that require IUID marking is documented in Appendix B.

2. Marking Considerations

There are numerous issues to consider when selecting the most appropriate marking method for an IUID project. At the very minimum, the Program Manager has to consider the cost of the system, materials and application; the reliability and durability of the IUID mark; and the potential for the physical mark to alter the form, fit, or function of the component. To further complicate the process, one marking method clearly is not sufficient for the M1A1 MBT—or any other platform for that matter. For example, external areas that are consistently exposed to harsh environmental conditions require a solution that may not be practical for internal components such as wire harnesses or cables.

a. Resiliency

The foremost priority should be choosing a method that produces a resilient human- and machine-readable mark that does not appreciably deteriorate over the lifecycle of the component it is intended to identify. Although there is not one method that is completely impervious to every conceivable environment where the M1A1

[16] Substitute and alternate NSNs represent parts that can be used if the principle part is not available. It is impossible for both a substitute or alternate part and the principle part to be on the tank at the same time. For the purposes of this research, only principle parts were considered to be mounted on the tanks.

MBT may operate, selecting a method that only serves to achieve initial compliance (e.g., applying an IUID sticker label to an engine) creates excessive burden and confusion for future logistical efforts and circumvents the intent of the IUID program.

b. Non-Intrusive

The marking method should be as non-intrusive as possible. While DPM has many advantages (such as longevity and space efficiency), this method should be reserved for OEMs rather than for marking legacy components, since universal application is difficult because of the different compositions and structural tolerances of items. Besides the potential to increase the fatigue of an object by laser-etching the surface, DPM could lead to costly errors and salvaged parts in instances of marking malfunctions or other difficulties. Similarly, drilling holes to attach IUID data plates may alter the form, fit, or function of the item and necessitate a deeper engineering analysis—which would cost considerably more—than compared to bonding the plate with a high-strength adhesive. An epoxy resin or Pressure-Sensitive Adhesive (PSA)[17] tape should be assessed to determine the merits of each bonding solution for applicability to the various marking surfaces of the M1A1 MBT.

c. Engineering Change Proposals

Engineering change proposals are required to ensure both that the items are properly marked and that the marking will not affect the form, fit, or function of the item to be marked. Since the technical data for the M1 series of tanks was never purchased from General Dynamics, their input is required to affect the majority of ECPs. The Army initially identified approximately 1,500 parts that potentially required

[17] The Marine Corps Prepositioning Program-Norway (MCPP-N) used a custom "peel and stick" adhesive tape manufactured by Avery Dennison to apply data plates to the PEI, engine, and transmission case of 41 USMC Medium Tactical Vehicle Replacement (MTVR) legacy assets during an IUID pilot program. The PSA tape—available commercially and known as XHA 9745— bonds immediately without cure time, withstands extreme temperatures of engine operation, and is not affected by pressure washing with cleaning solutions (Leibrandt, 2008).

IUID marking. They are working through that list in a four-phase approach.[18] So far, the Army has completed ECPs for 612 of those parts with regards to IUID marking. This effort has taken approximately 2.5 years but due to increased visibility on IUID compliance, the Army anticipates completing their review of the remaining parts and any additional ECPs by January or February of 2009. Due to the commonality between the Army version and the USMC version of the M1A1, the majority of ECPs required should be completed during the Army's efforts. Approximately 95% of the two versions of M1A1s are the same according to Mr. Jaaskelainen. Therefore, only 5% of the parts identified for marking in this project are assumed to be USMC-specific.

The cost of the 612 ECPs already completed totaled approximately $500,000. This equates to an average cost of $866.99 per ECP. This estimation includes only those parts unique to the USMC M1A1. Of the 775 parts identified as requiring IUID marking in this analysis, $775 * 5\% = 38.75 \text{ or } 39$, are deemed to be particular to the USMC M1A1. This equates to a total cost of $39 * \$866.99 = \$33{,}812.61$ for additional ECPs not covered by the Army's endeavor.

3. Marking Method

For the purposes of selecting the best marking method, the components of the M1A1 MBT are divided into three categories: 1) flat external and internal areas, 2) uneven or round external and internal areas, and 3) flexible or moving parts. This may be overly simplistic, but short of physically examining each part that meets IUID criteria, it serves as a preliminary reference until the M1A1 marking process gains momentum. The categories with the corresponding marking method are detailed below.

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[18] The Army's four phase plan for determining which items would require IUID marking is as follows:
Phase I – Major end-items
Phase II – LRUs with data plates
Phase III – LRUs without data plates
Phase IV – All other items within the DoD requirements criteria

a. Flat External and Internal Areas

It is assumed that the majority of the IUID-qualified components falls into this category in which anodized aluminum data plates—combined with a Neodymium-Doped Yttrium Aluminum Garnet (Nd:YAG) laser—can accommodate countless dimensions. Anodized aluminum data plates are an excellent choice to mitigate harsh environmental conditions in which high resistance to corrosion, abrasion, and indifference to temperature extremes is absolutely necessary.

Due to the durability and unyielding properties of the plate, many IUID pilot projects have experienced success employing anodized aluminum data plates. For example, the MCPP-N pilot program tested an anodized data plate[19] (Figure 4) manufactured by Monode Marking Products, Inc., that incorporates an inorganic dye—as opposed to the commonly used organic dye variant. Consequently, the data plate excels in extreme operating temperatures and boasts abrasion- and fade-resistant attributes that are superior to the organic dye variant.

Figure 4. Example of an Anodized Aluminum Data Plate

[19] According to the results of the MCPP-N IUID pilot program, the tested data plates—commercially known as "Black Plus"—were 2" x 4" with a thickness of 0.020" (approximately 0.069" with Avery Dennison XHA 9745 PSA tape). Besides being virtually indistinguishable from the organic dye variant, the blank data plates require a Nd:YAG laser to mark and meet the specifications of MIL-A-8625, Anodic Coatings for Aluminum and Aluminum Alloys.

b. Uneven or Round External or Internal Areas

This category includes those few areas that do not contain enough flat space for a standard data plate (e.g., main gun). Anodized aluminum foil is available in a range of thicknesses and is ideal for curved areas because of its inherent flexibility. Even though it is not as rigid as standard data plates, the anodizing process provides the same industrial benefits—such as resistance to chemicals, abrasion, and high temperatures. Figure 5 is an example of an anodized aluminum foil IUID data plate (UID Label & Beyond LLC, 2008).

Figure 5. Example of an Anodized Aluminum Foil Data Plate

c. Flexible or Moving Items

The final category includes items such as cables and wire harnesses. Polyimide labels—which are superior to polyester—offer greater tear resistance through high tensile strength and are frequently utilized in the circuit board industry in which product labeling must withstand high temperatures and various solvents. As illustrated in Figure 6, high-contrast readable text and a 2D matrix can be created on a polyimide label with just 10 watts of a CO_2 laser (Synrad, 2007).

Figure 6. Example of a Polyimide Data Label

d. Creating IUID-compliant Tags

For permanence, reliability and versatility, it is recommended that ANAD acquire an industrial, hybrid CO_2/Nd:YAG laser—such as the Trotec FineMarker Hybrid—for flexibility and to meet *MIL-STD-130N* requirements for IUID marking. The sharp contrast, high resolution and scalability of laser marking supports a wide range of dimensions and enables more data elements to be embedded into a UII data matrix than other methods. It is functional for many applications—including the aforementioned marking methods—and it can withstand the demand and high throughput of the depot. Furthermore, commercial data-management software—such as A2B's UID Comply!—can seamlessly integrate with existing systems or act as a stand-alone solution to create Construct 1 or 2 UII data, print and validate IUID-compliant labels, and successfully transmit compliance data to the IUID Registry. Lastly, a combination verifier/reader—like the Cognex DataMan 7550 handheld portable unit—can verify the quality of any 2D matrix and serve as a mobile reader.

4. Current Sustainment Rebuild Schedule

As mentioned in Chapter IV, once a tank meets the Combat Vehicle Evacuation (CVE) criteria for rebuild, the tank is shipped to ANAD, and the rebuild is conducted. The tank Program Manager's sustainment office in Albany, Georgia, is responsible for forecasting the number of tanks that are to be rebuilt each year at ANAD based on current operational tempos and budget forecasts. Table 2 illustrates the most recent forecast from the tank program management sustainment office for all 447 tanks to cycle through the rebuild process.

The rebuild cycle is an on-going effort that is assumed to remain constant for all three courses of action considered. Because of the combat operations in Iraq, the Marine Corps just completed an accelerated rebuild of all of its tanks. Since all of the tanks have effectively been set to zero in terms of CVE recently, there is currently a lower rate of rebuilds per year than what is anticipated in the future. Right now, the tank sustainment office plans to ramp up the rebuild process in FY2011 as the

Maritime Prepositioning Force (MPF) tanks start being rotated through rebuild process again.

Table 2. Current Rebuild Schedule

Fiscal Year	Quantity	Total
2010	13	13
2011	71	84
2012	71	155
2013	71	226
2014	71	297
2015	71	368
2016	71	439
2017	8	447

C. Normal Rebuild Schedule Proposal (COA 1)

The first Course of Action (COA) is IUID marking all tank legacy components on PEIs during the regular forecasted rebuild schedule at ANAD. There are benefits and shortfalls in terms of timing, cost, and feasibility to this course of action. One of the primary benefits is that the marking may be coordinated with an established process.

1. Process

The IUID marking process would be the same for each tank. Once a tank meets the CVE criteria and is placed on the schedule to be rebuilt, it will be shipped to ANAD. The facility conducts a complete disassembly of all components as part of the normal process. This method would require an office at the depot to create the IUID data plates for each part that has been identified for marking. When the plates are created, the part information would be submitted to the IUID Registry, and the part would be linked to the tank serial number to which it belongs. The plates would then be sent to the area where they would be applied to the parts. This method can

be completed merely by altering the Statement of Work used by the Marine Corps and ANAD to outline what work is to be completed during the rebuild process.

a. Benefits

The rebuild process takes approximately 54 days, which cannot be interrupted by the IUID marking of the legacy tank components. The rebuild schedule is forecasted, and all legacy tank components would receive IUID marking by FY2017. The opportunity is optimal because each tank and all of its components are completely disassembled as part of the normal rebuild process. The only added effort and cost is in the form of creating and applying the data plates to the components. Economies of scale at ANAD make the marking process less complicated and add flexibility to the schedule. The aforementioned benefits make this course of action appealing in terms of cost and feasibility.

b. Drawbacks

The one major shortfall with this course of action relates to the criteria of time. The December 2010 mandate for all IUID marking on legacy components would not be met using this course of action. As previously mentioned, complete component marking would not be accomplished until FY2017.

2. Cost Analysis

The main benefit of COA 1 from a cost perspective is that many of the costs are already incurred regardless of whether or not IUID marking takes place. In other words, much of the expense is considered sunk costs and so does not apply directly to the IUID implementation. For example, the Marine Corps has already established that the M1A1 tanks will be rebuilt based on the CVE criteria. Thus, the cost to ship these tanks to ANAD, fully disassemble and reassemble them, and then ship them back to the end-users will be incurred regardless of the IUID marking effort. This COA seeks to leverage that cost by taking advantage of the easy access to all of the parts when the tank is completely disassembled. Therefore, the only new costs associated with this COA are those above and beyond the normal rebuild

agreement. These costs include creating each label and the labor to apply those labels.

a. Cost per Label

The labels required for IUID marking can be obtained in one of two ways. The Marine Corps can require that ANAD provide the labels, or the Marine Corps can purchase the labels from a separate contractor and provide them to ANAD for application. The former option is considered more appropriate due to the large number of labels required across all platforms, the flexibility of having the capability in-house to change specifications and correct errors, and the ability to spread costs across numerous programs. The cost per label utilizing in-house capability is estimated at $3.38 per label[20] (Rains, 2007), which includes labor, material, and registry. This figure is in FY07 dollars. This cost was derived from an analogous program at Tobyhanna Army Depot (TYAD) with the following cost breakdown:

- Material Cost: $0.08/label
- Cost to create label: $2.81/label
- Cost to enter label into registry: $0.49/label

The total cost of labels is, therefore, calculated as $1,217,051. See Table 3.

[20] The estimate from TYAD originally included labor costs to affix the labels. However, since labels in this COA will be affixed by personnel on the M1A1 rebuild line at ANAD, it is deemed more appropriate to use cost data available pertaining to their hourly rate.

Table 3. Total Cost of Labels for COA 1

447	tanks
* 775	labels per tank
* 3.38	per label FY07$
$ 1,170,917	total cost of labels in FY07$
* 1.0394	Inflation factor[21]
$1,217,051	total cost of labels in FY09$

b. Labor Cost

The researchers estimated the labor cost to apply all of the labels by determining approximately how long it should take to apply each label on average, multiplying that number by the number of labels to get the average number of hours associated with application, and then multiplying that number by the average hourly salary of the label applicators. According to Mr. Joe Gordon Chief, Unit Mission Costing Division, Assistant Secretary of the Army for Financial Management and Comptroller (ASA (FM&C)) Cost & Economics, the average loaded hourly labor rate at ANAD across the M1A1 production line is $178 (FY07$). The time required to apply an IUID label depends upon the type and location of the label. On average, though, the time to apply an IUID label is estimated to be 5 minutes or .0833 hours. Therefore, the total cost for labor to apply labels under this implementation method is estimated at $5,338,963. See Table 4.

[21] The inflation factor was derived from the inflation calculator available at the Naval Center for Cost Analysis website (http://www.ncca.navy.mil/services/inflation.cfm).

Table 4. Total Cost of Labor for COA 1

447	tanks
* 775	labels per tank
346,425	labels
* .0833	hours per label
* 178	dollars per hour FY07$
$5,136,582	total cost of labor in FY07$
* 1.0394	Inflation factor
$5,338,963	total cost of labor in FY09$

c. Total Cost

The total cost to implement COA 1 is, therefore, estimated to be $1,217,051 for the labels plus $5,338,963 for the labor to apply them—or $6,556,014 total. This equates to roughly $14,667 per tank.

D. Focused Depot-level Effort Proposal (COA 2)

The second course of action proposed is an accelerated IUID implementation schedule that would send tanks to ANAD solely for part marking. Due to current budget projections, this program would not be funded until FY2010, which would mark the beginning of the marking schedule, in a process that would be similar to the first course of action. The tanks would not need to be rebuilt as they pass through ANAD, though, since they would not have met CVE criteria yet.

1. Process

A schedule for all tanks to be shipped from its originating unit to ANAD would be established. The current production line may have to be modified, or a separate production line may have to be created, since the tanks are not being routed through the normal rebuild cycle. As mentioned earlier, the rebuild cycle in Table 2 would not change, so tanks would still come to ANAD for rebuild. The tanks going through the

rebuild process during this time would receive IUID marking as described in the first course of action.

The tanks being shipped to ANAD only for marking would be disassembled as needed to reach the required parts listed in Appendix B. The data plates would be created, and the information would be entered into the IUID Registry. The parts would be marked as soon as they become available, and then the tank would be reassembled. The completed tanks would then be returned to their originating units. The schedule for this COA would still begin in FY2010 due to the same budget constraints as COA 1.

a. Benefits

The main advantage of COA 2 is that it allows for the utilization of ANAD's full capacity to process tanks. Mr. Jaaskelainen stated that currently, ANAD can process 20 tanks per month through its rebuild lines without increasing labor or facilities capacity. The tank sustainment office stated that it can have as many as 59 tanks off line without impacting readiness or ongoing operations. Thus, this COA could theoretically be completed in less than 2 years.[22] However, one limiting factor to this course of action is the rotation of MPF ships, since maintenance is only performed once every three years. So, if this COA begins in 2010, it would still take a minimum of three years to reach all of the tanks aboard MPF ships. The possibility of bringing in ships early was explored but was determined to be unreasonable due to national security concerns. According to Mr. John Sipes, Deputy Commander for Logistics at Blount Island Command (BIC), Jacksonville, Florida, the level of authority to make changes to the MPF ship rotation is at Joint Chiefs of Staff level and higher, with concurrence from combatant commanders. Therefore, the earliest this COA could be completed would be in FY2012. The timing is a benefit to this method in relation to COA 1 but still will not meet the 2010 deadline.

[22] 447 tanks/20 tanks per month = 22.35 months

b. Drawbacks

The most notable weakness to this COA is the incremental cost to execute it. Approximately 292 tanks, or 65% of the total, would be shipped to ANAD only for part marking, so the full cost of shipping and working on these tanks must be borne by this program. As mentioned, the accelerated IUID implementation schedule would still not meet the December 2010 deadline.

2. Cost Analysis

This proposal does not enjoy the same cost savings associated with leveraging the current rebuild effort. Since the tanks would be sent to ANAD specifically to have the appropriate parts marked, all costs associated with transportation and disassembly/assembly must be applied to the program as well as the costs to make and apply the labels. Some cost savings would be achieved since the Marine Corps can still take advantage of the ongoing rebuild program to mark those 155 tanks.

a. Transportation Costs

Some assumptions have been made in relation to the transportation costs. First, it is assumed that the 36 tanks in Iraq will be returned to CONUS based on a normal rotation schedule within the four years that it takes to implement this course of action. Thus, the cost to bring those tanks from Iraq would not be incurred. Additionally, it is assumed that the tanks currently stored at ANAD would make their way back to the operating forces over the course of this program. Therefore, the costs to transport the tanks to ANAD would be estimated based on the normal table of organization for the USMC tank community.

The cost to rail head and then truck two tanks from the east coast to ANAD is approximately $19,000, according to Mr. Duponte, and the same method to ship tanks from the west coast costs approximately $23,000. Since these costs are for two tanks round trip, the overall cost to and from ANAD is approximately $19,000 from the east coast and $23,000 from the west coast per tank. Typically,

approximately 30% of the tanks must be shipped from the west coast, which includes 1st Tank Bn, the EEAP tanks, and most of 4th Tank Bn. The rest would come from the east coast—including the MPF tanks from BIC, 2nd Tank Bn, and part of 4th Tank Bn. It has not yet been determined exactly which of the 155 tanks will meet CVE criteria for rebuild. So, it is assumed that of the remaining 292 tanks, 30% will be shipped from the west coast, and the remainder will come from the east coast. Thus, the transportation costs for this COA are $5,900,000. See Table 5.

Table 5. Total Transportation Costs for COA 2

East Coast	West Coast
292 * 70% = 204 tanks	292 * 30% = 88 tanks
* $19,000	* $23,000
= $3,876,000	= $2,024,000

Total transportation cost are	$3,876,000
+	$2,024,000
	$5,900,000

b. Disassembly/Reassembly Costs

Each tank would not have to be fully disassembled to reach the necessary parts, and several parts can be marked while on the tank. However, many components would have to be removed and then further disassembled to mark embedded parts. The time to do this is difficult to approximate, but one expert, Mr. Jaaskelainen, suggested it could be as much as 2,000 man-hours per tank. This analysis uses 2,000 hours as a point estimate, but will also show how a 25% increase or decrease in required labor would affect this portion of the total cost (based on guidance from the expert that the variation in hours should not exceed this range). Analysis results are shown in Table 6.

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Table 6. Cost of Assembly/Disassembly for COA 2

	- 25%	Point	+ 25%
Number of tanks	292	292	292
Number of man hours	* 1500	* 2000	* 2500
Dollars per hour FY07$	* 178	* 178	* 178
Total cost in FY07$	$ 77,964,000	$ 103,952,000	$ 129,940,000
Inflation factor	* 1.0394	* 1.0394	* 1.0394
Total cost in FY09$	$81,035,781	$108,047,708	$135,059,636

c. Total Cost

The total cost to implement COA 2 is, thus, estimated to be $6,556,014 to acquire materials and apply the IUID labels,[23] plus $5,900,000 to transport the 292 tanks that will not be marked during the normal rebuild process, plus $108,047,708 for the additional labor required to disassemble and reassemble those 292 tanks—for a total of $120,503,722. This equates to $269,583 per tank.

E. Mobile Marking Team Proposal (COA 3)

The third course of action involves sending depot-level fielding teams to mark the vehicles at their respective points of origin. Other programs have had some success with similar methods; however, programs with PEIs that possess highly technical components, such as the M1A1 tank community, run into unique challenges with this proposal. It quickly became apparent that this method would be very complex, which called into question its feasibility. Some of the issues pertaining to this course of action are considered here, but an in-depth analysis is beyond the

[23] This cost is the same as COA 1.

scope of this project. Overall, the complexity of this method and the numerous obstacles that must be overcome make this a less-than-ideal course of action.

One of the appeals of this COA is that it may accomplish the marking in less time than COA 1, although it faces the same budgetary constraints as the other two COAs and could not make the December 2010 deadline. Furthermore, the exact time that it would take for a mobile marking team to disassemble the tank far enough to reach all of the necessary parts, mark them, and then test and reassemble the tank and the various components is difficult to estimate. It certainly would take longer than the focused effort at ANAD, though, and might take as long as or longer than COA 1. Additionally, this course of action would directly impact the operations of the using units, unlike COAs 1 and 2. Finally, Mr. Jaaskelainen stated that it would likely not be economically feasible to remove certain parts for marking except during an overhaul or rebuild of the component. Apart from economic feasibility, it may not be practical to disassemble certain components in the field, even if special equipment required to do so were transported to each site. Any time certain components are disassembled, special equipment is required; in addition, certain pieces, such as seals, must be replaced. Then, each component is tested, since damage often occurs to other sensitive pieces during the process—a danger that has been largely mitigated at the depot. It is generally recommended that these components be shipped to the depot for repair, a feat that would only add to the cost and time of this COA.

VI. Summary, Conclusion and Recommendations

A. Summary

This project consisted of a review of IUID technology, the USMC version of the M1A1 MBT, and the associated maintenance. Technology, history, policy and on-going DoD initiatives for IUID implementation were covered. The analysis of the project consisted of identifying the legacy components on the PEI M1A1 tank that require IUID marking and exploring three potential IUID implementation strategies to achieve IUID compliance.

The first proposed plan suggested implementing IUID marking during the current tank rebuild cycle at ANAD, which would be completed no earlier than FY2017. The second implementation plan proposed a concerted effort to rotate tanks through ANAD specifically for part marking. This proposal would be concurrent with the rebuild schedule and could potentially be completed by FY2012. The last plan proposed using a depot-level fielding team to mark the tanks at their current locations. Each plan was considered in terms of timing, costs, and feasibility.

The three plans evaluated the advantages and disadvantages associated with the various aspects of IUID marking. Special thought was given to tank operational conditions, marking methods, and the timing for implementation completion. Consideration was also given to the costs involved in each plan as summarized in Table 7. The vast amount of variables in the third plan negated the viability of that proposal.

Table 7. Summary of Total Costs per Course of Action

	Labeling Costs	Transportation Costs	Assembly and Disassembly Costs	Total Cost
Course of Action 1	$6,556,014	$0	$0	$6,556,014
Course of Action 2	$6,556,014	$5,900,000	$108,047,708	$120,503,722
Course of Action 3	Recommended for further analysis			

B. Conclusion

One of the primary goals of this research project is to determine if the USMC M1A1 tank community is sufficiently prepared to meet the December 2010 IUID compliance mandate for legacy components. From the perspective of ANAD, where it is estimated that 80% of all IUID marks will be applied to the M1A1, the answer is unequivocally "no." Few depot personnel have knowledge of IUID, and even fewer perceive any benefit to implementation. The current IUID on-site capability is defined by processes that were created during pilot projects, but they are not adequate to support the throughput of the M1A1 line. Furthermore, ANAD maintenance personnel identified only one component—the M1A1 engine—that had been marked thus far by an M1A1 OEM.

It is not surprising that IUID compliance is still several years away. Instituting an invasive technology throughout the DoD that will modernize AIT systems and increase material readiness through item-unique lifecycle management is a monumental challenge. Nevertheless, resource constraints have forced the DoD to reconsider its traditional dependence on excessive inventories and leverage unique identification technologies to optimize force readiness.

1. Implementation Strategy

To minimize interruption of operational availability and reduce the cost incurred with uniquely identifying components on the M1A1 MBT, the optimal

implementation strategy is to opportunistically mark the tank during its normal rebuild schedule at ANAD. Besides having access to a completely disassembled tank during the rebuild process—which would occur regardless of IUID—the Marine Corps will avoid the excessive labor and transportation costs associated with an accelerated IUID-focused effort at ANAD or the overly complex and obstacle-laden solution of a depot-level fielding team. An industrial, hybrid Nd:YAG/CO_2 laser system, appropriate data plates and an IUID management suite that includes software interface with the IUID Registry and an UII verifier/reader would provide ANAD with the capability to support not only M1A1 throughput, but all of its IUID requirements.

2. Impediments to Meeting the 2010 Mandate

Quite simply, the IUID policy office does not expect compliance by 2010. With only approximately 4% of an estimated 100 million IUID-qualified items marked and registered presently, a more realistic estimate might be no sooner than 2020 for the DoD. For the USMC M1A1 tank community, it is nearly impossible to achieve compliance for legacy items earlier than the middle of the next decade. Notwithstanding budgetary constraints, perhaps the biggest impediment is achieving total marking saturation on operational assets that are dispersed globally. In some cases—such as M1A1 MBTs located on the three MPSRONs—it is not feasible to mark anything more than the PEI and other major components because of space restrictions or lack of support resources.

The configuration control process is another significant impediment to implementation. In addition to the availability of budgetary resources, the configuration control process will dictate the pace of IUID implementation, especially with regard to modifying any component. Extensive testing will have to occur to determine if a data plate or DPM affects the form, fit, or function of a component, while engineering drawings will require an update to specify the placement of the applicable marking. Each IUID proposal will necessitate a coordinated engineering

analysis and, at the very minimum, a Class II ECP to be routed through a very regimented and formal configuration control process.

The last significant impediment is integrating IUID capability at ANAD. Besides the required material resources and systems to produce IUID-compliant data plates, analysis and reconfiguration of the assembly line would have to occur, along with training and demonstration. Among the three impediments to implementation, this is by far the easiest challenge to overcome.

C. Recommendations

While the M1A1 tank program will not achieve IUID compliance by December 2010, there are some productive steps that the Program Office can accomplish prior to the depot achieving IUID FOC. First, the Program Office can begin assigning and registering virtual UIIs for all legacy items that have been identified and scheduled to eventually receive the physical UII mark. This would ensure that the item—along with its associated acquisition and maintenance pedigree—is entered into the IUID Registry. When the components are ultimately marked through a trigger event such as depot maintenance, then the virtual UII will be changed to a compliant UII in the registry. Secondly, there are an increasing number of vendors that offer comprehensive IUID solutions—to include transforming data plates into IUID-compliant tags that conform to *MIL-STD-130N*. Once the IUID tag is incorporated into user-level maintenance instructions, the pre-printed data plates can be distributed to the tank battalions to apply to the major components of the M1A1 MBT (e.g., PEI, the turret and gun barrel, etc.), thereby reducing some of the burden on ANAD.

Recommendations for further research include:

- A cost-benefit analysis of DPM on legacy items at the depot-level,
- An analysis of the impact of the IUID mandate on the configuration control process,

- A pilot program to analyze and develop a non-intrusive bonding agent for the external surfaces of the tank that will excel in challenging operating environments, and
- Further analysis and development of the cost and feasibility to utilize depot-level fielding teams to achieve IUID compliance.

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Appendix A. M1A1

A. M1A1 Specifications

Table 8. M1A1 Specifications

M1A1 Specifications	
Manufacturer	General Dynamics (Land Systems Division)
Crew	4: Commander, Gunner, Loader & Driver
Weight	63 tons
Length (Gun Forward)	387 inches
Turret Height	93.5 inches
Width	144 inches
Ground Clearance	19 inches
Ground Pressure	13.8 PSI
Obstacle Crossing	42 inches
Vertical Trench	9 feet
Power plant	AGT-1500 turbine engine
Power Rating	1500 HP
Power to Weight Ratio	23.8 hp/ton
Hydro Kinetic Transmission	4 Speed Forward 2 Speed Reverse
Speed—Maximum	42 mph (Governed)
Speed—Cross Country	30 mph
Speed—10% Slope	20 mph
Speed—0% Slope	4.5 mph
Acceleration	7 seconds
(0 to 20 mph)	
Cruising Range	275 miles
Main Armament	120mm M256 Smooth Bore Cannon
Commander's Weapon	.50 Cal M2 Machinegun
Coaxial Weapon	7.62 M240 Machinegun
Loader's Weapon	7.62 M240 Machinegun on Skate Mount
NBC System	200 SCFM - Clean Cooled Air
Inventory	447 USMC

B. Description of the M1A1

In order to convey the complexity of the M1A1 Abrams MBT, the following excerpt from Jane's Information Group 2008 is included. This passage describes in great detail the various workings and systems of the M1A1 and gives the reader the most comprehensive unclassified understanding of this weapon system that the authors have found.

> The hull and turret of the M1A1 is of advanced armour construction similar to the Chobham armour developed in the UK and provides protection against ATGWs and other battlefield weapons.
>
> The driver is seated at the front of the vehicle in the centre and operates the vehicle from a semi-reclining position when driving with the hatch closed. Steering is accomplished by rotating a motorcycle-type T-bar, which actuates the steering lever on the transmission to produce the steering speed bias of the track. At both ends of the T-bar are twist grip controls, which serve as the throttle for the electronic fuel management system. The condition of fluid levels, filters, batteries, electrical connectors and circuit breakers are displayed on the driver's maintenance monitoring panel. The driver is provided with a single hatch that opens to the right with three integral day periscopes for observation when the hatch is closed. The centre day periscope can be replaced by an image intensification periscope for night driving.[1] The driver has a 120° field of view, and his night driving periscope will fit into the loader's periscope housing for night-time surveillance. This can be of the image intensification or thermal type.
>
> The commander and gunner are seated on the right of the turret and the loader on the left. The commander is provided with six day periscopes which cover 360°, as well as a day sight with a magnification of ×3 for the .50 (12.7 mm) M2 HB machine gun mounted over his position and an optical extension of the gunner's primary sight. The gunner has a primary sight (GPS) with dual day optics with a magnification of ×10 (narrow field of view), magnification of ×3 (wide field of view), close-in surveillance magnification of ×1 and an 18° field of view, thermal imaging night vision optics with a magnification of ×10 (narrow field of view), magnification of ×3 (wide field of view), sight stabilisation in elevation and a Raytheon Systems Company laser range-finder. The turret is stabilised in azimuth with a gyro reticle compensation (gyroscope) drive to keep the aim point on target in deflection.
>
> The gunner's auxiliary day sight (a Kollmorgen Model 939) has a magnification of ×8 and an 8° field of view. The loader is provided with a single day periscope with a magnification of ×1, which can be traversed through 360°.
>
> The fire-control system includes the laser range-finder, full-solution solid-state digital computer supplied by General Dynamics Canada and stabilised day/thermal night sight. The

[1] The driver's night vision periscope has since been replaced with a thermal viewer. In addition to providing better clarity and visibility, the main advantage of this upgrade is that it allows the driver to operate the tank in daylight as well as night-time and limited visibility situations. This eliminates the need for the driver to swap the day and night periscopes as conditions change, particularly at dusk and dawn, which previously would hamper operational tempo.

stabilisation system permits accurate firing on the move, and the gunner merely places his reticle in GPS (a graticule is used in the gunner's auxiliary sight) on the target and uses the laser range-finder (Nd:YAG) to determine the range. The computer then determines and applies the weapon sight offset angles necessary to obtain a target hit, and the gunner opens fire. The main 120 mm smoothbore M256 armament is equipped with a muzzle reference system to measure the bend of the gun tube. Information from a wind sensor mounted on the turret roof and a pendulum static cant sensor at the turret roof centre is fed automatically to the computer together with inputs from the laser range-finder and the lead angle. The following data are manually set: battle sight range, ammunition type, barrel wear, muzzle reference compensation, barometric pressure and ammunition temperature.

The infra-red Thermal Imaging System (TIS)[2] has been developed by the Raytheon Systems Company and produces an image by sensing the small difference in heat radiated by the objects in view. The detected energy is converted into electrical signals, which are displayed on a cathode ray tube, similar to a TV picture, and the image displayed is projected into the eyepiece of the gunner's sight. In addition, the sight displays target range information and indicates if the laser range-finder has received more than one return. The operator can select a first or last return mode for lasing the target before firing. Ready to fire indication and confirmation that the systems are working properly are also provided.

The thermal imaging system generates a reticle pattern boresighted to the day graticule and to the laser range-finder. This allows the gunner to operate the TIS just as he would the day sight. The infra-red sight is based on use of common modules, components standardised to specifications of the US Army Night Vision and Electro-Optics Center.

The digital fire-control computer is produced by General Dynamics Canada. The fire-control computer hardware consists of an electronics unit and a separate data entry and test panel. The electronic unit contains the computing element, the power regulators and interfaces with other elements of the fire-control system. The entry and test panel contain the keyboard, control switches and indicators, and a numeric display. The fire-control computer carries out a continuous monitoring of its internal function and memory, and provides a visual display of any malfunction. A manually initiated self-test facility gives fault diagnosis in either unit of the system to the replaceable subassembly level.

Power for the electrohydraulic gun and turret drive system is provided by an engine-driven pump through a slip-ring in the turret/hull interface, to a power valve in the manifold beneath the main armament.

The crew compartment is separated from the fuel tanks by armour bulkheads. Sliding armour doors and armour-protected boxes isolate the crew from onboard main armament ammunition explosion. An automatic Halon fire extinguishing system in the tank reacts to the outbreak of a fire in 2 ms and extinguishes fire in less than 250 ms. Ready use 120 mm ammunition is stowed in the turret bustle and in the event of penetration by a HEAT projectile, the explosion would blow off the top panels with the crew being protected by the access doors normally kept in the closed position. The loader holds the switch closed with his knee

[2] In December 2004, the US Marine Corps Systems Command signed a Milestone C Decision for full production of the M1A1 Tank Firepower Enhancement Program (FEP). This will be installed on all US Marine Corps M1A1 MBTs and includes the second-generation forward-looking infrared (FLIR) sight, north-finding module and far-target locator (FTL) function, and eye-safe laser range-finder (Jane's, 2008). This system is in the process of being fielded.

to keep the doors open. The doors close automatically when the pressure switch is relieved. In addition to venting upwards, the turret bustle magazine vents to the rear.

All production M1 series MBTs are powered by a Lycoming Textron AGT 1500 gas turbine.[3] The engine operates primarily on diesel or kerosene-based fuel, but can operate on petrol during emergencies. Approximately 70 per cent of the engine accessories and components can be removed without removing the power pack from the tank. The complete power pack can be removed and replaced in less than an hour compared with 4 hours for the M60 series. The gas turbine delivers more horsepower to the sprocket than a comparable diesel engine because of the low cooling requirement. The exhaust for the gas turbine is at the rear of the hull with the air inlet on the hull top. Production of the AGT 1500 turbine engine was completed in 1992 after 12,162 were built.

The engine is coupled to an Allison Transmission X-1100-3B fully automatic transmission with four forward and two reverse speeds. The transmission also provides integral brakes, variable hydrostatic steering and pivot steering.

The improved torsion bar suspension has rotary shock-absorbers at the first, second and seventh roadwheel stations with 381 mm of roadwheel travel compared with 162 mm in the M60 series. The top of the suspension is protected by vertical armoured skirts, which hinge outwards to allow access to the suspension for maintenance. The drive sprocket is at the rear with the idler at the front and there are two return rollers. Standard equipment includes an AN/VDR-1 (RADIAC) Radiological Warning Device, a chemical agent detector kit, a collective NBC protection unit and personnel heaters.

The turret was originally designed to accept the standard 105 mm M68 series rifled gun (which is the barrel of the now BAE Systems Land Systems 105 mm L7 with a US developed breech mechanism) or the German Rheinmetall 120 mm smoothbore gun which has the US designation M256.

The US decided to adopt the 120 mm Rheinmetall smoothbore gun for the M1. The final production decision was taken in December 1984 and the first production M1 with the 120 mm gun, designated M1A1, was completed in August 1985.

Gun/turret integration was carried out by General Dynamics. The new gun mount is similar to that employed on the basic 105 mm M1 MBT. Software changes to the computer were made on completion of firing table data collection. The ammunition racks, blow-off panels and crew compartment sliding door were redesigned.

Mounted coaxially to the right of the main armament is a 7.62 mm M240 machine gun, and a similar weapon skate-mounted on the left side of the turret for the loader can be elevated from -30 to +65°, total traverse being 265°. A total of 11,400 rounds of 7.62 mm machine gun ammunition is carried. Mounted at the commander's station is a standard .50 (12.7 mm) Browning M2 HB machine gun which can be elevated from -10 to +65° and traversed through 360°. This weapon has powered and manual controls for traverse and manual controls for elevation. The .50 (12.7 mm) machine gun has electric power traverse and can be aimed and fired from within the turret. A total of 1,000 rounds of .50 (12.7 mm) machine gun ammunition

[3] US Army engines are being upgraded under the TIGER program. The TIGER program includes a complete rebuild of the engine (versus a simple overhaul) with many major components replaced with completely new parts. Marine Corps engines are also undergoing many of the same upgrades.

is carried. Mounted on either side of the turret is a British-designed (L8A1) six-barreled smoke grenade discharger designated the M250.

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Appendix B. Equipment Inventory

	NOMENCLATURE	NSN	SMRC	PRICE
1	ACCUMULATOR,HYDRAULIC	3040005080126	PAOFF	$73.03
2	ACTUATOR ASSEMBLY	1015012554159	PAFFF	$715.00
3	ACTUATOR,ELECTRO-MECH	3010013220161	PAFFF	$181.00
4	ACTUATOR,HYDRAULIC-	4810011967737	PADDD	$1,978.00
5	ACTUATOR,HYDRAULIC-	4810013378962	PAHDD	$12,804.00
6	ADAPTER AND SHAFT A	3040011528805	PADDD	$3,344.00
7	ADAPTER,SPLINE	3040014251531	PAOOO	$49.70
8	ADAPTOR,HOST	7010013028669	PAFDD	$254.43
9	ADJUSTER,SLACK,TRACK	2530011662343	PAOHH	$956.00
10	AIR CLEANER,INTAKE	2940013137824	PAFOO	$10,102.00
11	AIR DIFFUSER,TURBIN	2835012013480	PBDDD	$20,810.00
12	AMPLIFIER ASSEMBLY	5895011771612	PAFDD	$42,014.00
13	AMPLIFIER,AUDIO FREQUENCY	5996012843057	PAODD	$2,361.00
14	AMPLIFIER,CONTROL,F	2540010729932	PAOOO	$1,584.00
15	AMPLIFIER,VIDEO	5895011461390	PAFDD	$1,346.00
16	AMPLIFIER-FREQUENCY MULTIPLIER	5895014072627	PAODD	$1,610.00
17	ANTENNA	5985010170784	PAOOO	$171.00
18	ARM ASSEMBLY,PIVOT,TRACK SUSPENSION	2530010635668	PAOOO	$551.00
19	ARM ASSEMBLY,PIVOT,TRACK SUSPENSION	2530010635856	PAODD	$1,629.00
20	ARMATURE ASSEMBLY	2920013053831	PAOHH	$201.80
21	ARMATURE,EXCITER	6125012870723	PADDD	$1,584.00
22	ARMOR SET,SUPPLEMEN	9515015377533	PAOOO	$23,792.39
23	ARMOR,SUPPLEMENTAL,SMALL ARMS-FRAGMENT PROTECT	2540010719047	PAOOO	$685.00
24	ARMOR,SUPPLEMENTAL,SMALL ARMS-FRAGMENT PROTECT	2540013445892	PBDZA	$8,014.00
25	AUXILIARY CONTROL	5855010377342	PAFDD	$807.00
26	AZIMUTH DRIVE ASSEM	1240013249345	PAFDD	$13,984.00
27	BACKPLANE ASSEMBLY	5998011164913	PAFFF	$395.00
28	BACKPLANE ASSEMBLY	5998012407329	PAODD	$4,417.00
29	BAFFLE PLATE ASSEMBLY	1240012514852	PAFDD	$3,882.00
30	BASE,ASSEMBLY	5120011600631	PAOOO	$1,238.40
31	BASE,BEARING PULLER	5120012017875	PAOZZ	$5,354.98
32	BATTERY,STORAGE	6140014469498	PAOFA	$125.26
33	BEARING UNIT,BALL	3130012014830	PAHDD	$1,312.00
34	BEARING UNIT,BALL	3130012056003	PAHHH	$358.02
35	BEARING UNIT,ROLLER	3130010743491	PADDD	$895.00
36	BEARING,BALL,ANNULA	3110010730735	PADDD	$975.00
37	BEARING,BALL,ANNULA	3110010743600	PADDD	$97.22
38	BEARING,BALL,ANNULA	3110010786004	PADDD	$295.00
39	BEARING,BALL,ANNULA	3110010899832	PADDD	$286.00
40	BEARING,BALL,ANNULA	3110010915532	PADDD	$318.00
41	BEARING,BALL,ANNULA	3110010934420	PADDD	$90.07

	NOMENCLATURE	NSN	SMRC	PRICE
42	BEARING,BALL,ANNULA	3110010957681	PADDD	$113.00
43	BEARING,BALL,ANNULA	3110010970341	PADDD	$447.00
44	BEARING,BALL,ANNULA	3110011612132	PADDD	$452.00
45	BEARING,BALL,ANNULA	3110011995469	PAHDD	$2,276.00
46	BEARING,PLAIN,ROD END	3120011458982	PAFFF	$574.00
47	BEARING,ROLLER,CYLINDRICAL	3110010729964	PADDD	$476.00
48	BEARING,SLEEVE	3120011645842	PADDD	$163.00
49	BELL CRANK	3040013363655	PAOOO	$653.00
50	BIOCULAR IMAGE CON	2350015370505	PAOLL	$17,315.47
51	BLOCK ASSEMBLY,SERVO	2520011151546	PADZZ	$6,115.00
52	BODY ASSEMBLY	5855014164501	PADDD	$6,233.06
53	BODY,VALVE	2530010737704	PAODD	$165.00
54	BOX,ACCESSORIES STOWAGE	2540012739510	PAOOO	$302.00
55	BOX,AMMUNITION STOWAGE	2541012544774	PAOOO	$939.00
56	BRACKET,LEVER	5340010787618	PAFFF	$83.81
57	BRACKET,MOUNTING	5340010866786	PAFFF	$328.00
58	BRACKET,MOUNTING	5340011222233	PADDD	$414.00
59	BRACKET,MOUNTING	5340011760744	PAFZZ	$7,186.00
60	BRAKE ASSEMBLY	1015011803512	PAFHH	$2,060.00
61	BREECH MECHANISM	1015011654845	PAFFD	$45,523.00
62	CABLE AND CONDUIT A	6150013808962	PAODD	$1,371.00
63	CABLE ASSEMBLY,CONTROL	2590013201292	PAOOO	$276.00
64	CABLE ASSEMBLY,POWER,ELECT	5995002629381	PAHDD	$86.09
65	CABLE ASSEMBLY,POWER,ELECT	5995012922881	PBDDD	$890.00
66	CABLE ASSEMBLY,POWER,ELECT	6150010729994	PAOFF	$269.00
67	CABLE ASSEMBLY,POWER,ELECT	6150011313678	PAOFF	$989.00
68	CABLE ASSEMBLY,POWER,ELECT	6150011428271	PAFFF	$748.00
69	CABLE ASSEMBLY,PRINTED,FLEXIBLE	6150010748957	PAFDD	$1,649.00
70	CABLE ASSEMBLY,PRINTED,FLEXIBLE	6150011678315	PADDD	$774.00
71	CABLE ASSEMBLY,PRINTED,FLEXIBLE	6150012181622	PADDD	$1,438.00
72	CABLE ASSEMBLY,SPEC	2590011303450	PAOFF	$1,310.00
73	CABLE ASSEMBLY,SPEC	5995010787652	PBDDD	$41.52
74	CABLE ASSEMBLY,SPEC	5995011054006	PAOFF	$112.00
75	CABLE ASSEMBLY,SPEC	5995011208558	PAOFF	$258.00
76	CABLE ASSEMBLY,SPEC	5995011208559	PAOFF	$275.00
77	CABLE ASSEMBLY,SPEC	5995015641645	PAOLL	$580.00
78	CABLE ASSEMBLY,SPEC	6150010729985	PAFFF	$88.04
79	CABLE ASSEMBLY,SPEC	6150010766743	PAFDD	$4,170.00
80	CABLE ASSEMBLY,SPEC	6150010787760	PAFFF	$143.00
81	CABLE ASSEMBLY,SPEC	6150010787761	PAFFF	$239.00
82	CABLE ASSEMBLY,SPEC	6150011285590	PAOFF	$306.49
83	CABLE ASSEMBLY,SPEC	6150011285591	PAOFF	$351.92
84	CABLE ASSEMBLY,SPEC	6150011285592	PAOFF	$416.46
85	CABLE ASSEMBLY,SPEC	6150011285593	PAOFF	$309.00
86	CABLE ASSEMBLY,SPEC	6150011285594	PAOFF	$224.37

	NOMENCLATURE	NSN	SMRC	PRICE
87	CABLE ASSEMBLY,SPEC	6150011285595	PAOFF	$342.98
88	CABLE ASSEMBLY,SPEC	6150011764781	PAODD	$5,954.00
89	CABLE ASSEMBLY,SPEC	6150012718016	PAOFF	$162.00
90	CABLE ASSEMBLY,SPEC	6150013847895	PAOFF	$183.00
91	CABLE ASSEMBLY,SPEC	6150014583849	PAOFF	$3,479.00
92	CABLE KIT,SPECIAL POWER	2590001487961	PAOOO	$361.00
93	CAM,CONTROL	3040012864881	PAFHD	$245.48
94	CANISTER,HATCH,DRIV	2510014127832	PAOFF	$749.92
95	CANT UNIT ASSEMBLY	1015012720862	PAODD	$961.00
96	CAP,FILLER OPENING	2590010991473	PAOOO	$851.74
97	CAP,FILLER OPENING	2910010991474	PAOOO	$529.76
98	CAP,FILLER OPENING	5430011081100	PAOOO	$455.00
99	CAP,PORT ASSEMBLY	2910011364344	PBDDD	$940.00
100	CARRIER ASSEMBLY	2520011681483	PAHDD	$2,484.00
101	CARRIER,PLANETARY REDUCTION GEAR,NONAIR	2835010729953	PAFHH	$1,445.00
102	CARRIER,PLANETARY REDUCTION GEAR,NONAIR	2835010754916	PAHDD	$1,291.00
103	CARRIER,PLANETARY REDUCTION GEAR,NONAIR	2835011657029	PAFDD	$3,734.00
104	CARRIER,PLANETARY REDUCTION GEAR,NONAIR	2835012003106	PAHDD	$8,498.00
105	CASE AND STATOR,GAS TURB ENG	2835010899185	PADDD	$15,123.00
106	CASE SET,TRANSPORT	8115011450465	PAFFF	$524.00
107	CASE,AXIAL COMPRESSOR,TURBINE ENG	2835010730166	PADDD	$2,843.00
108	CELL ASSEMBLY,OPTIC	1240012540659	PAFDD	$1,053.00
109	CELL ASSEMBLY,OPTIC	1240012736079	PAFDD	$2,498.00
110	CELL ASSEMBLY,OPTIC	1240012739774	PADFD	$684.00
111	CELL ASSEMBLY,OPTICAL INSTRUMENT	1240012027929	PAFZZ	$7,688.00
112	CHAMBER,COMBUSTION,NONAIR	2835010740021	PADDD	$722.00
113	CHASSIS,ELECTRICAL-ELEC	5821010761787	PBDDD	$1,814.00
114	CHASSIS,ELECTRICAL-ELEC	5999012711456	PAFDD	$936.00
115	CHUTE ASSEMBLY,AMMUNITION	1015012574163	PAOOO	$328.00
116	CIRCUIT CARD ASSEMB	5998010781308	PBDDD	$122.00
117	CIRCUIT CARD ASSEMB	5998010783885	PBDDD	$4,032.00
118	CIRCUIT CARD ASSEMB	5999010814195	PBDDD	$319.00
119	CIRCUIT CARD ASSEMBLY	5998010730162	PAFDD	$1,413.00
120	CIRCUIT CARD ASSEMBLY	5998010749021	PAFDD	$1,149.00
121	CIRCUIT CARD ASSEMBLY	5998010749022	PAFDD	$752.00
122	CIRCUIT CARD ASSEMBLY	5998010761883	PADDD	$5,974.00
123	CIRCUIT CARD ASSEMBLY	5998010761884	PADDD	$1,195.00
124	CIRCUIT CARD ASSEMBLY	5998010766901	PAFDD	$1,336.00
125	CIRCUIT CARD ASSEMBLY	5998010778974	PAFBZ	$89.72
126	CIRCUIT CARD ASSEMBLY	5998010781307	PAFFF	$454.00
127	CIRCUIT CARD ASSEMBLY	5998010793082	PAFFF	$113.00
128	CIRCUIT CARD ASSEMBLY	5998010949640	PAFDD	$1,151.00
129	CIRCUIT CARD ASSEMBLY	5998010949643	PAFDD	$3,237.00
130	CIRCUIT CARD ASSEMBLY	5998011290502	PADDD	$2,489.00
131	CIRCUIT CARD ASSEMBLY	5998011354516	PAFDD	$841.00

	NOMENCLATURE	NSN	SMRC	PRICE
132	CIRCUIT CARD ASSEMBLY	5998011387033	PAFDD	$2,185.00
133	CIRCUIT CARD ASSEMBLY	5998011623922	PAFDD	$1,457.00
134	CIRCUIT CARD ASSEMBLY	5998011687229	PAFDD	$6,495.00
135	CIRCUIT CARD ASSEMBLY	5998011688122	PAFDD	$1,775.00
136	CIRCUIT CARD ASSEMBLY	5998011688124	PAFDD	$6,143.00
137	CIRCUIT CARD ASSEMBLY	5998011695372	PAFDD	$9,748.00
138	CIRCUIT CARD ASSEMBLY	5998011695374	PAFDD	$1,142.00
139	CIRCUIT CARD ASSEMBLY	5998011720000	PAFDD	$626.00
140	CIRCUIT CARD ASSEMBLY	5998011720001	PAFDD	$560.00
141	CIRCUIT CARD ASSEMBLY	5998011720002	PAFDD	$799.00
142	CIRCUIT CARD ASSEMBLY	5998011720010	PAFDD	$6,049.00
143	CIRCUIT CARD ASSEMBLY	5998011879757	PAODD	$3,910.00
144	CIRCUIT CARD ASSEMBLY	5998011906210	PAFDD	$2,459.00
145	CIRCUIT CARD ASSEMBLY	5998011978323	PAFDD	$1,055.00
146	CIRCUIT CARD ASSEMBLY	5998011978324	PAFDD	$1,185.00
147	CIRCUIT CARD ASSEMBLY	5998011980722	PAFDD	$2,068.00
148	CIRCUIT CARD ASSEMBLY	5998011980723	PAFDD	$2,829.00
149	CIRCUIT CARD ASSEMBLY	5998011980724	PAFDD	$1,776.00
150	CIRCUIT CARD ASSEMBLY	5998012000128	PAFDD	$726.00
151	CIRCUIT CARD ASSEMBLY	5998012060084	PAFDD	$2,009.00
152	CIRCUIT CARD ASSEMBLY	5998012172431	PADDD	$956.00
153	CIRCUIT CARD ASSEMBLY	5998012172432	PADDD	$1,848.00
154	CIRCUIT CARD ASSEMBLY	5998012738394	PAFDD	$1,519.00
155	CIRCUIT CARD ASSEMBLY	5998012752583	PADDD	$1,323.00
156	CIRCUIT CARD ASSEMBLY	5998012755523	PAFFF	$544.00
157	CIRCUIT CARD ASSEMBLY	5998012985739	PAFDD	$9,114.00
158	CIRCUIT CARD ASSEMBLY	5998013022821	PAFLL	$536.22
159	CIRCUIT CARD ASSEMBLY	5998013037858	PAFDD	$636.00
160	CIRCUIT CARD ASSEMBLY	5998013189807	PAFDD	$2,931.00
161	CIRCUIT CARD ASSEMBLY	5998013235205	PAFDD	$861.00
162	CIRCUIT CARD ASSEMBLY	5998013410396	PAFDD	$17,743.00
163	CIRCUIT CARD ASSEMBLY	5998014120928	PAFZZ	$5,918.86
164	CIRCUIT CARD ASSEMBLY	5998014569848	PAFDD	$1,116.00
165	CIRCUIT CARD ASSEMBLY	5998014599484	PAFDD	$840.00
166	CIRCUIT CARD ASSEMBLY	5998015000576	PAODD	$10,377.00
167	CIRCUIT CARD ASSEMBLY	5998015000579	PAODD	$2,698.00
168	CIRCUIT CARD ASSEMBLY	5998015066659	PAODD	$7,596.00
169	CIRCUIT CARD ASSEMBLY	5998015107494	PAODD	$8,235.00
170	CIRCUIT CARD ASSEMBLY	5998015107495	PAODD	$3,725.00
171	CIRCUIT CARD ASSEMBLY	5999010745828	PAFDD	$772.00
172	CIRCUIT CARD ASSEMBLY	5999010766888	PAFDD	$1,786.00
173	CIRCUIT CARD ASSEMBLY	5999010835741	PAFDD	$4,521.00
174	CIRCUIT CARD ASSEMBLY	5999011325221	PAFDD	$944.00
175	CIRCUIT CARD ASSEMBLY	5999011623924	PADDD	$1,383.00
176	CIRCUIT CARD ASSEMBLY	5999011768769	PAFDD	$1,179.00

	NOMENCLATURE	NSN	SMRC	PRICE
177	CIRCUIT CARD ASSEMBLY	5999011846653	PAFHH	$1,039.00
178	CIRCUIT CARD ASSEMBLY	5999011846654	PAFHH	$1,341.00
179	CIRCUIT CARD ASSEMBLY	5999011846655	PAFHD	$1,357.00
180	CIRCUIT CARD ASSEMBLY	5999011988956	PAFDD	$1,888.00
181	CIRCUIT CARD ASSEMBLY	5999012011157	PAFDD	$1,136.00
182	CIRCUIT CARD ASSEMBLY	5999012087065	PAFDD	$997.00
183	CIRCUIT CARD ASSEMBLY	5999012242780	PAFDD	$1,802.00
184	CIRCUIT CARD ASSEMBLY	5999012407357	PAODD	$4,124.00
185	CIRCUIT CARD ASSEMBLY	5999012520192	PAFDD	$885.00
186	CIRCUIT CARD ASSEMBLY	5999012540807	PAHHD	$1,104.00
187	CIRCUIT CARD ASSEMBLY	5999012597709	PAFDD	$6,274.00
188	CIRCUIT CARD ASSEMBLY	5999012711466	PAFDD	$2,777.00
189	CIRCUIT CARD ASSEMBLY	5999012800349	PADDD	$1,643.00
190	CIRCUIT CARD ASSEMBLY	5999012800350	PADDD	$743.00
191	CIRCUIT CARD ASSEMBLY	5999013410416	PAFDD	$2,692.00
192	CIRCUIT CARD ASSEMBLY	5999013434203	PAFDD	$2,294.00
193	CIRCUIT CARD ASSY	5999012853797	PAFDD	$10,186.00
194	CLAMP,MATERIAL LIFT	3940012042698	PAFFF	$957.00
195	CLUTCH ASSEMBLY,FRICTION	2520010673899	PAOHD	$418.00
196	COLLIMATOR,INFINITY AIMING REFERENCE	1240014750276	PAOFA	$1,240.00
197	COMMUNICATOR ASSEMBLY	4910012391634	PAOFD	$4,302.00
198	COMPRESSOR ROTOR,AXIAL-CENTRIFUGAL,TURBINE ENGINE	2835010737786	PAFZZ	$19,049.00
199	COMPRESSOR,ASSEMBLY	5120011995457	PAFFF	$177.00
200	COMPRESSOR,GUN RECO	4933012958135	PAFFF	$3,358.00
201	COMPRESSOR,GUN RECOIL SPRING	4933012048684	PAOOO	$823.00
202	COMPUTER, FIRE CONTROL	1220013720720	PAOFF	$30,089.00
203	CONNECTING LINK,RIGID	3040013477498	PAOFF	$857.00
204	CONNECTOR BODY,PLUG,ELECTRICAL	5935013183908	PAOOO	$163.00
205	CONNECTOR,PLUG,ELECTRICAL	5935012173281	PAFFF	$310.40
206	CONNECTOR,RECEPTACL	5935010941418	PADDD	$443.00
207	CONSOLE,POWER DISTR	6110012664006	PAOFD	$5,283.00
208	CONTACT ASSEMBLY,EL	5999011980632	PAFDD	$24,859.00
209	CONTAINER,REUSABLE SHIPPING AND STORAGE	8145015370288	PAOLL	$1,161.80
210	CONTROL ASSEMBLY	1240012510561	PAFDD	$1,634.00
211	CONTROL ASSEMBLY	5825011980524	PAFDD	$15,539.00
212	CONTROL ASSEMBLY,PUSH-PULL	2590013201294	PAOOO	$277.00
213	CONTROL BOX ASSEMBLY	2590012770059	PAOOO	$478.85
214	CONTROL HANDLE,ASSE	1015012049984	PAOFF	$2,163.00
215	CONTROL,INDICATOR	5895013823221	PAODD	$2,745.00
216	CONTROL,INTERCOMMUNICATION SET	5830013823218	PAODD	$1,313.00
217	CONTROL,MODULATOR	5895013674205	PAFDD	$3,337.00
218	CONTROL-DISPLAY,OPT	5980014804875	PAODD	$8,065.00
219	CONTROL-DISPLAY,OPT	5980015251688	PAOFF	$3,803.00
220	CONTROLLABLE INTER	4910012719248	PAODD	$16,480.00
221	CONTROLLER,AIR TEMP	2540011858217	PAOHH	$4,172.00

	NOMENCLATURE	NSN	SMRC	PRICE
222	COOLER,CRYOGENIC,ME	5855011159014	PADDD	$3,531.00
223	COOLER,FLUID,TRANSMISSION	2520010673874	PAODD	$928.00
224	COOLER,LUBRICATING OIL,ENG	2930010673839	PAODD	$1,306.00
225	COUPLING,SHAFT,RIGI	3010011967738	PADDD	$141.00
226	COVER ASSEMBLY,CONN	2590011596215	PAFDD	$2,368.00
227	COVER ASSEMBLY,POWER CONTROL UNIT	1240011164513	PAFFF	$125.00
228	COVER ASSEMBLY,SUPPORT HOUSING	1240012750071	PAFFF	$1,344.00
229	COVER,ACCESS	5340010738019	PAOHH	$854.00
230	COVER,ACCESS	5340010761874	PBFFF	$206.00
231	COVER,ACCESS	5340010781301	PBFFF	$289.00
232	COVER,ACCESS	5340010787755	PBFFF	$707.00
233	COVER,ACCESS	5340010833132	PAFFF	$136.58
234	COVER,ACCESS	5340010985156	PAFFF	$80.97
235	COVER,ACCESS	5340011953782	PBFFF	$169.00
236	COVER,ACCESS	5340012319150	PAOZZ	$7,135.45
237	COVER,ACCESS	5340012746342	PAFFF	$678.00
238	COVER,BRAKE,STEERING	2530011194098	PAOHH	$525.24
239	COVER,COMBUSTOR	2835012142642	PAOFD	$812.00
240	COVER,ELECTRICAL CONNECTOR	5935013177616	PBFDD	$3,360.00
241	COVER,ELECTRICAL RELAY	5945012770326	PAOOO	$2,030.00
242	COVER,HYDRAULIC,PUMP-MOTOR	4320011192649	PADDD	$561.00
243	COVER,SHIPPING AND STORAGE	8145012496437	PAFFF	$307.00
244	COVER,TERMINAL BOARD	5940011177954	PAFFF	$87.87
245	COVER,TRANSMISSION	2520010737693	PAHDD	$5,183.00
246	CRADLE,CANNON	1015012628613	PAFDD	$28,154.00
247	CRANK ASSEMBLY	1015011803510	PAHHH	$675.00
248	CRANK ASSEMBLY	1015012059660	PAOOO	$41.97
249	CRANK ASSEMBLY,BREECHBLOCK	1015012128474	PAOOO	$2,596.00
250	CUPOLA,COMMANDER'S	2510010748916	PBFZZ	$5,450.06
251	CYLINDER ASSEMBLY,ACTUATING,LINEAR	3040013385960	PAOFF	$3,805.00
252	CYLINDER ASSY,COOLI	2835010740014	PADDD	$2,804.00
253	DETECTOR COOLER ASS	1240012736038	PAFDD	$28,799.00
254	DETENT ASSEMBLY	1240012736039	PAFFF	$640.00
255	DIFFERENTIAL,STEERING CONTROL	2520012006113	PAHDD	$5,316.00
256	DIFFUSER ASSEMBLY	2540012005821	PAOOO	$605.00
257	DISC ASSEMBLY	1015011194005	PAFHH	$912.00
258	DISK AND BLADE ASSEMBLY	2835010737787	PADDD	$5,640.00
259	DISK AND HUB,TURBINE,NONAIR	2835012185946	PADDD	$6,810.00
260	DISK ASSEMBLY,COMPR	2835010737784	PADDD	$5,133.00
261	DISK CARTRIDGE,MAGNETIC	7045013031492	PAFDD	$792.35
262	DISK,FLEXIBLE	7045013031489	PAFDD	$94.11
263	DISK,GAS TURBINE EN	2835010985164	PADDD	$2,456.00
264	DISK,LIGHT INTERRUP	6625013667237	PAFDD	$1,478.00
265	DISK,TURBINE,TURBIN	2835010737775	PADDD	$5,208.00
266	DISPLAY CONTROL MOD	5980015644347	PAOLL	$17,323.00

	NOMENCLATURE	NSN	SMRC	PRICE
267	DISTRIBUTION BOX	6110012859848	PAOFD	$4,644.00
268	DISTRIBUTION BOX	6110014976960	PAOFD	$26,885.00
269	DOOR ASSEMBLY,AMMUNITION	1240012486852	PAFDD	$5,995.00
270	DOOR,HATCH,VEHICLE	2510012006216	PAOZZ	$6,324.30
271	DOOR,VEHICULAR	2510013279439	PAFOO	$430.00
272	DRIVE UNIT,ANGLE	3010010690484	PAOFF	$2,117.00
273	DRIVE UNIT,ANGLE	3010011787479	PAFHH	$5,930.00
274	DRIVE UNIT,ELECTROH	1015011229401	PAFDD	$6,421.00
275	DUMMY CONNECTOR,PLUG	5935011528799	PAFFF	$153.25
276	EJECTOR ASSEMBLY,AIR	4320011811702	PAOOO	$516.00
277	ELECTONIC CONTROL	5963013179799	PCOFD	$22,758.00
278	ELECTRONIC COMPONEN	5998012631814	PAFDD	$617.00
279	ELECTRONIC COMPONEN	5999011714774	PAOFD	$10,525.00
280	ELECTRONIC COMPONEN	5999011906175	PAOFF	$17,877.00
281	ELECTRONIC CONTROL	2590011964716	PBOFD	$8,833.00
282	ELECTRONIC CONTROL	5963014225412	PAOFF	$4,162.00
283	ELECTRONIC CONTROL	5963014746208	PCODD	$27,414.00
284	ELECTRONIC UNIT,FIRE CONTROL COMPUTER	1220013837026	PAOFF	$6,617.00
285	ELECTRONIC UNIT,FIRE CONTROL COMPUTER	1220015315874	PAOFD	$32,058.00
286	ELECTRONIC UNIT,FIRE CONTROL COMPUTER	5998013568543	PAOFF	$114,050.00
287	ELEVATING MECHANISM	1015013926553	PAFHH	$5,958.00
288	END BELL,ELECTRICAL	6105011400277	PAHHH	$79.00
289	END BELL,ELECTRICAL ROTATING EQUIP	2920010168472	PADDD	$777.00
290	ENGINE MODULE FORWA	2835012691234	PAFDD	$229,331.00
291	ENGINE MODULE REAR	2835011787245	PAFDD	$199,185.00
292	ENGINE,GAS TURBINE,	2835015482910	PAOLL	$549,562.00
293	EXERCISER,RECOIL ME	4933013461791	PAOFF	$10,262.00
294	EXHAUST SYSTEM,ENGINE	2990013173927	PAOOO	$3,433.27
295	EXTINGUISHER,FIRE	4210011791059	PAOFD	$1,090.00
296	EYEPIECE ASSEMBLY,O	1240010792885	PAFFF	$992.00
297	FAN,VANEAXIAL	4140014068167	PAOHH	$3,808.00
298	FENDER,VEHICULAR	2510011662049	PAODD	$4,841.00
299	FILTER ASSEMBLY,FLUID	2910011014127	PAOOO	$200.00
300	FILTER BODY,FLUID	2940012006157	PAOFF	$786.00
301	FILTER ELEMENT,INTAKE AIR CLEANER	2940014069209	PAOOO	$304.00
302	FILTER,FLUID	2910004672580	PBOOO	$249.61
303	FILTER,FLUID	2910011176645	PAOOF	$480.00
304	FILTER,FLUID	4330012003104	PAOOO	$87.18
305	FILTER,GAS-PARTICULATE	4240011613710	PAOOO	$877.00
306	FILTER-SEPARATOR,LIQUID FUEL	4930013058430	PAOOO	$82.24
307	FINAL DRIVE AND CON	2520011674282	PAOFD	$9,704.00
308	FORDING KIT,DEEP WA	2540013006502	PAOOO	$13,036.00
309	FRAME SECTION,STRUCTURAL,VEHICULAR	2510011150451	PAFHH	$794.00
310	FUEL CONTROL,MAIN,TURBINE ENGINE	2910010809132	PAOHD	$8,540.00
311	FUEL SYSTEM ASSEMBL	2910013390029	PAODD	$20,781.00

	NOMENCLATURE	NSN	SMRC	PRICE
312	GAGE,CANNON BORE EROSION	5210012805223	PAFFD	$4,946.00
313	GEAR CLUSTER	3020010899184	PADDD	$469.00
314	GEAR LOCK ASSEMBLY	1015011815924	PAHHH	$197.00
315	GEAR,BEVEL	3020010743661	PADDD	$807.00
316	GEAR,INTERNAL	3020011583067	PAFFF	$1,055.77
317	GEAR,SPUR	3020010743486	PADZZ	$6,775.07
318	GEARBOX ASSEMBLY,CW	1015010766691	PAOFF	$13,059.00
319	GEARBOX, ACCESSORY DRIVE, TURBINE ENGINE	2835011978325	PAFDD	$47,763.00
320	GEARBOX,ACCESSORY DRIVE,TURB ENG	2835010737756	PAFFF	$72.59
321	GEARBOX,ACCESSORY DRIVE,TURB ENG	2835011364356	PAHHH	$2,295.00
322	GEARBOX,ACCESSORY DRIVE,TURB ENG	2835011364357	PAOHD	$1,583.00
323	GEARSHAFT,BEVEL	3040012029863	PAOOO	$94.60
324	GEARSHAFT,SPUR	3040010734095	PAHHH	$399.00
325	GEARSHAFT,SPUR	3040010764391	PADDD	$352.00
326	GENERATOR, ENGINE ACCESSORY	2920013058419	PAODD	$17,426.00
327	GENERATOR,ALTERNATING CURRENT	6115010748971	PAOZZ	$5,459.00
328	GENERATOR,NOISE	6625013184380	PAFDD	$36,476.00
329	GRILLE,METAL	2510013173949	PBOOO	$8,559.11
330	GRIP ASSEMBLY,CONTR	1290010728044	PAFFF	$1,022.00
331	GRIP ASSEMBLY,CONTR	1290010766740	PAOHH	$5,077.00
332	GRIP ASSEMBLY,CONTR	1290010766865	PAOHH	$3,458.00
333	GRIP ASSEMBLY,CONTR	1290010814167	PAFFF	$262.00
334	GRIP ASSEMBLY,CONTR	1290010839012	PAFFF	$1,047.00
335	GRIP ASSEMBLY,CONTR	1290014282547	PAOHH	$3,458.00
336	GRIP ASSEMBLY,CONTR	1290014292389	PAOFD	$547.00
337	GUARD,MECHANICAL DRIVE	2835010730725	PADDD	$1,519.00
338	GUARD,MECHANICAL DRIVE	2835010730733	PAFDD	$722.00
339	GUARD,MECHANICAL DRIVE	3020012960785	PAOOO	$131.00
340	GUN SHIELD,FRONT	1015012305776	PAFZA	$5,239.00
341	GUN SHIELD,REAR	1015012305775	PBFZA	$5,863.00
342	HALF-PACK ASSEMBLY	2835012661111	PADZZ	$11,974.82
343	HAND PUMP ASSEMBLY	4320012010814	PAOFF	$2,966.00
344	HANDLE,MANUAL CONTROL	5340010985163	PBOOO	$770.56
345	HARNESS ASSEMBLY,CONVERTER	1240011164511	PADDD	$481.00
346	HEAD ASSEMBLY,GUNNE	1240012685117	PAFFD	$9,132.00
347	HEADLIGHT	6220010835673	PAOOO	$43.99
348	HEADREST,SEAT,VEHICULAR	2540012308803	PAOOO	$497.02
349	HEATER, ELECTRIC,FILTER UNIT	4240008076856	PAOFF	$210.00
350	HEATER,VEHICULAR,COMPARTMENT	2540011695159	PAOFD	$5,540.00
351	HELMET,COMBAT VEHICLE CREWMANS	8470014672108	PAOFF	$614.10
352	HINGE,DOOR,VEHICULAR	2510010748917	PAOFF	$1,157.00
353	HOLDER ASSEMBLY,ELE	5977011150573	PAHHH	$542.41
354	HOLDER,AMMUNITION	1398013307983	PAOOO	$511.00
355	HOLDER,AMMUNITION	1398013309532	PAOOO	$471.00
356	HOLDER,AMMUNITION	1398013313014	PAOOO	$499.00

	NOMENCLATURE	NSN	SMRC	PRICE
357	HOLDER,AMMUNITION	1398013319044	PAOOO	$621.00
358	HOLDER,MAINTENANCE FIXTURE,MULTIPOSITION	4910013290713	PAHDD	$247.00
359	HOLDER,OPTICAL ELEMENT	1240011816018	PBFFF	$153.00
360	HOOK AND HOUSING ASSEMBLY	1015013922309	PAOOO	$936.00
361	HOSE ASSEMBLY,NONMETALLIC	4720013561605	PAOOO	$1,497.00
362	HOSE ASSEMBLY,NONMETALLIC	4720013855404	PAOFF	$545.00
363	HOUSING AND PRECLEA	4240008076858	PAOFA	$714.00
364	HOUSING ASSEMBLY	2920012489629	PAFFF	$238.00
365	HOUSING ASSEMBLY,NO	2835011615335	PAFDD	$741.00
366	HOUSING ASSEMBLY,TURRET LOCK	1015011290260	PAFFF	$272.00
367	HOUSING ASSY	2520011704900	PBFFD	$2,223.00
368	HOUSING SECTION,FUEL PUMP	2910011192648	PADDD	$480.00
369	HOUSING,MECHANICAL DRIVE	2520012056022	PAHDD	$22,065.00
370	HOUSING,MECHANICAL DRIVE	3040010729959	PADDD	$14,011.00
371	HOUSING,MECHANICAL DRIVE	3040010730721	PAODD	$5,767.00
372	HOUSING,MECHANICAL DRIVE	3040011428248	PAOZZ	$7,650.50
373	HOUSING,MECHANICAL DRIVE	3040011978098	PADDD	$20,551.00
374	HOUSING,MECHANICAL DRIVE	3040012014837	PADDD	$10,182.00
375	HOUSING,MECHANICAL DRIVE	3040012114298	PAHDD	$20,815.00
376	HOUSING,MECHANICAL DRIVE	5998015493439	PAODD	$5,762.00
377	HOUSING,ACTUATOR	2540013614855	PADDD	$178.00
378	HOUSING,AMMUNITION	1015011953971	PAOOO	$3,151.00
379	HOUSING,AMMUNITION RACK	1015012060879	PAODD	$6,336.00
380	HOUSING,ANTIFRICTION BEARING,NONAIR	2835010743787	PADDD	$270.00
381	HOUSING,ANTIFRICTION BEARING,NONAIR	2835010764125	PADDD	$1,506.00
382	HOUSING,ASSEMBLY FR	2910011361437	PADDD	$788.00
383	HOUSING,ELECTRICAL	5825011719839	PAFDD	$6,248.00
384	HOUSING,ELECTRONICS	1240010761815	PBFFF	$830.00
385	HOUSING,FAN,TUBEAXIAL	2930011364341	PAHHH	$983.97
386	HOUSING,FRONT VANE,COOLING FAN AND DRIVE	2835011408447	PAFHH	$1,047.96
387	HOUSING,GEARBOX,TUR	2835011787379	PADDD	$2,909.00
388	HOUSING,MECHANICAL	5340012663899	PAOHH	$517.00
389	HOUSING,MECHANICAL DRIVE	2520011479925	PAHHH	$814.00
390	HOUSING,MECHANICAL DRIVE	2835011805549	PADDD	$13,905.00
391	HOUSING,MECHANICAL DRIVE	3040010730118	PAFDD	$1,084.00
392	HOUSING,MECHANICAL DRIVE	3040010730121	PADDD	$1,714.00
393	HOUSING,MECHANICAL DRIVE	3040010743489	PADDD	$7,181.00
394	HOUSING,MECHANICAL DRIVE	3040011209809	PADZZ	$8,964.00
395	HOUSING,MECHANICAL DRIVE	3040011662189	PAFDD	$1,075.00
396	HOUSING,MECHANICAL DRIVE	3040012076570	PAHHH	$752.81
397	HOUSING,MECHANICAL DRIVE	3040012228004	PADDD	$3,468.00
398	HOUSING,MECHANICAL DRIVE	3040012557887	PAHDD	$3,721.00
399	HOUSING,MECHANICAL DRIVE	3040012557939	PADHH	$1,442.33
400	HOUSING,MECHANICAL DRIVE	3040012615235	PADDD	$1,877.00
401	HOUSING,MECHANICAL DRIVE	3040012648826	PAHDD	$16,379.00

	NOMENCLATURE	NSN	SMRC	PRICE
402	HOUSING,MECHANICAL DRIVE	3040012664019	PAFDD	$2,392.00
403	HOUSING,REAR VANE,COOLING FAN AND DRIVE	2835011408446	PAFHH	$3,043.00
404	HOUSING,REDUCTION G	2835011602605	PADDD	$4,552.00
405	HOUSING,STEERING COLUMN	2530010635678	PAOOO	$2,450.00
406	HOUSING,TORSION BAR	2510013450860	PAOZZ	$8,082.62
407	HUB,WHEEL,VEHICULAR	2530010635666	PAOOO	$206.00
408	IMPELLER,FAN,AXIAL	2930010730066	PADDD	$5,561.00
409	IMPELLER,FAN,AXIAL	2930012106296	PAFDD	$1,524.00
410	IMPELLER,FAN,AXIAL	4140012073577	PBHDD	$835.00
411	INSTALLATION KIT,EL	5895013608306	PAFFD	$3,794.44
412	INTERCOMMUNICATION	5830013954177	PAODD	$19,017.00
413	KEYBOARD,DATA ENTRY	7025013031490	PAFDD	$223.07
414	KEYBOARD,DISPLAY	5825011687134	PAFDD	$8,187.00
415	KIT,TRACK	1015012042686	PAFFF	$4,604.00
416	LAMP ASSEMBLY	6240013993009	PAFZZ	$6,039.26
417	LAMP,INCANDESCENT	6240011791061	PAOFF	$708.00
418	LASER RANGEFINDER W CONTAINER	1240012642040	PAODD	$28,128.00
419	LATCH,DOOR,VEHICULAR	2540012643058	PAOOO	$232.90
420	LAUNCHER,GRENADE,ARMAMENT SUBSYSTEM	1055000000138	PAOOO	$519.00
421	LEAD,ELECTRICAL	6150010766787	PAOFF	$155.00
422	LEFT SWING FRAME ASSEMBLY	1015014287657	PAOOO	$1,328.00
423	LENS ASSEMBLY	1240012683009	PAFFD	$6,140.00
424	LEVER,MANUAL CONTROL	5340011772655	PAOOO	$262.00
425	LIFTER,ROAD WHEEL	5120013568827	PAOOO	$435.00
426	LIFTING KIT	4933011084933	PAOOO	$660.00
427	LIFTING MECHANISM	2590012770060	PAOFF	$6,299.00
428	LIFTING TOOL ASSEMBLY	4910011249299	PAOOO	$2,566.11
429	LIFTING TOOL,HUB AN	4910011272712	PAOOO	$2,647.42
430	LIGHT,DOME	6220011956637	PAOFF	$227.00
431	LINER ASSEMBLY,DIFF	2835010740023	PADZZ	$5,970.00
432	LOCK ASSEMBLY,TURRET	1015010745746	PAOFF	$2,053.00
433	LOCK,TRAVELING,CANNON	1015013677794	PAOFF	$1,794.00
434	LOUDSPEAKER,PERMANENT MAGNET	5965013823222	PAOOO	$318.00
435	MAGNETIC TAPE DRIVE	7010013028670	PAOFD	$7,159.01
436	MAINTENANCE FIXTURE	4910012090613	PAFZZ	$8,256.00
437	MAINTENANCE,ELECTRICAL CONNECTOR	5935013441073	PAOZZ	$9,289.00
438	MANIFOLD ASSEMBLY	1015012518645	PAOOO	$251.00
439	MANIFOLD ASSEMBLY,HYDRAULIC	4730013153360	PAOHD	$2,127.00
440	MANIFOLD,HYDRAULIC SYSTEM ACCESS	4730010737737	PAHHH	$219.80
441	MANUAL DRIVE ASSEMBLY	1015012388186	PAFHH	$3,507.00
442	MANUAL DRIVE ASSEMBLY	1015013865575	PAOFF	$758.00
443	MATRIX ASSEMBLY,REG	2835011855767	PADDD	$34,757.00
444	METER,TIME TOTALIZING	6645015373114	PAODD	$740.00
445	MIRROR,OPTICAL INSTRUMENT	6650010792887	PAFFF	$385.00
446	MODIFICATION KIT, ENGINE ACCESSORIES	2940014347200	PAFHH	$28,020.00

	NOMENCLATURE	NSN	SMRC	PRICE
447	MODIFICATION KIT,FIRE CONTROL EQUIP	1240013256564	PAODD	$393.00
448	MODULATOR-OSCILLATO	5895011160279	PAFDD	$1,280.00
449	MODULE ASSEMBLY, NOR	5855015077394	PAFLL	$28,800.00
450	MODULE,POWER SUPPLY	5895011501033	PAFDD	$1,920.00
451	MOLDBOARD, LEFTSIDE	2590012767043	PAOOO	$10,929.57
452	MOLDBOARD, RIGHTSIDE	2590012767037	PAOOO	$10,611.71
453	MONOBROMOTRIFLUOROMETHANE,TECHNICAL	6830005558837	PAOFF	$128.55
454	MOTOR,DIRECT CURRENT	6105011375109	PAHHH	$528.90
455	MOTOR,HYDRAULIC	4320010759295	PAOFF	$2,179.00
456	MOUNT ASSEMBLY	1015012290618	PAOOO	$118.00
457	MOUNTING BASE,ELECTRICAL EQUIPMENT	5975012351962	PAOFH	$1,418.00
458	MOUNTING FLANGE ASY	4320011368770	PADDD	$1,985.00
459	MOUNTING FRAME	2590012776902	PAOZZ	$13,136.76
460	NORTH FINDING MODU W/ EMBEDDED GPS	5895015662804	PAOLL	$46,719.11
461	NOZZLE,DISTRIBUTION,WATER	4730012461231	PAOOO	$260.00
462	NOZZLE,FUEL INJECTION	2910012142640	PAOFD	$1,555.00
463	NOZZLE,FUEL INJECTION	2910012278897	PAOFF	$652.00
464	NOZZLE,TURBINE,NONA	2835014925795	PAODD	$8,692.00
465	NUT,PLAIN,ROUND	5310012038401	PAOOO	$261.00
466	OBJECTIVE AND RELAY	1240011924058	PAFDD	$2,622.00
467	OIL PUMP ASSEMBLY,ENG	2990010743488	PAODD	$8,668.00
468	ORGANIZATIONAL SET,	5180011360968	PAOOO	$3,647.00
469	OUTPUT,SHAFT ASSEMBLY	2520011441533	PAFHH	$2,593.76
470	PAD EYE	5340013700632	PAFFF	$464.00
471	PANEL, VEHICULAR OPERATION	2510014631438	PAOFD	$11,915.00
472	PANEL,CONTROL,ELECT	1290013688586	PAOFF	$3,303.00
473	PANEL,CONTROL,ELECT	1290013845683	PAOFF	$4,848.00
474	PANEL,CONTROL,ELECT	1290015119539	PAOFF	$6,053.00
475	PANEL,CONTROL,ELECT	1290015316007	PAOFF	$4,770.00
476	PANEL,CONTROL,ELECT	1290015354804	PAOFF	$2,419.00
477	PANEL,INDICATING,LI	6220014780849	PAOHH	$2,761.00
478	PANEL,POWER DISTRIBUTION	6110011600632	PAFFF	$860.63
479	PANEL,TEST,ELECTRICAL	6625011974203	PBHHH	$478.21
480	PANEL,VEHICULAR OPERATION	2510010730020	PAOFF	$451.00
481	PARTS KIT, FAN	4140013823597	PAODD	$10,242.00
482	PARTS KIT,AIR CONDITIONER	4130013816907	PAODD	$3,736.00
483	PARTS KIT,CELL ASSEMBLY	1240012783843	PAFFD	$332.00
484	PARTS KIT,HAND BRAKE	2530010899134	PAOOO	$3,887.45
485	PARTS KIT,HYDRAULIC	4320010866793	PAOZZ	$9,510.00
486	PARTS KIT,PRECOOLER	2540013777871	PAOFD	$9,637.00
487	PARTS KIT,PRESSURE REGULATING VALVE	4810013705458	PAODD	$4,108.00
488	PARTS KIT,SEPARATOR	2530013776935	PAOFD	$453.00
489	PARTS KIT,SUPERCHARGER	2990011538253	PAOFD	$445.00
490	PARTS KIT,VALVE	4810013776936	PAOFD	$1,985.00
491	PARTS KIT,VALVE	5999011764796	PAFDD	$1,787.00

	NOMENCLATURE	NSN	SMRC	PRICE
492	PARTS,KIT,ELECTRONIC EQUIP	5999011308077	PAFFF	$2,399.00
493	PERISCOPE,ARMORED VEHICLE	1240013195340	PAOOO	$666.00
494	PERISCOPE,ARMORED VEHICLE	1240013703674	PAODD	$13,246.00
495	PERISCOPE,TANK	1240012599095	PAODD	$4,585.00
496	PERISCOPE,TANK	6650013027684	PAOOO	$412.00
497	PISTON DEPRESSOR KIT	1015012042677	PAFFF	$1,544.00
498	PISTON, LINEAR ACTUATING CYLINDER	3040011774140	PAFDD	$15,332.00
499	PLATE ASSEMBLY,HYDR	2520013235391	PADDD	$1,600.50
500	PLATE ASSEMBLY,OIL	2520010841227	PADDD	$272.00
501	PLATE ASSEMBLY,VALVE	2590011863607	PADDD	$153.00
502	PLATE,END ASSEMBLY	2530011791087	PAFFF	$344.00
503	PLATE,MOUNTING	5340010740012	PADDD	$1,346.00
504	PLATE,MOUNTING	5340011995439	PAHDD	$574.00
505	PLATE,RETAINING,SEAL	5340013448849	PADDD	$156.00
506	PLATE,RETAINING,SHAFT	3040010737792	PADDD	$925.00
507	PLATE,RETAINING,SHAFT	3040013450548	PAOOO	$2,901.31
508	PLENIUM,AIR INTAKE	2540011290265	PAOZZ	$5,497.12
509	PLUG,PROTECTIVE,DUST AND MOISTURE SEAL	5340013279417	PAFOO	$209.00
510	PLUNGER,DETENT	5340013335869	PAOOO	$231.00
511	PLUNGER,SOLENOID	5945011134674	PAHHH	$42.99
512	POWER CONTROL UNIT	1240012045765	PAOFF	$7,936.00
513	POWER CONTROL UNIT	5998011868475	PAOFF	$1,766.00
514	POWER CONTROL UNIT, W CONTAINER	6130015370537	PAOLL	$11,751.61
515	POWER PACK WITH CON	2835014657020	PAODD	$782,278.00
516	POWER SUPPLY	6130011220690	PAFDD	$4,711.00
517	POWER SUPPLY	6130013022820	PAFDD	$456.59
518	POWER SUPPLY	6130015293094	PAOLL	$11,618.00
519	POWER SUPPLY ASSEMB	6130011980536	PAFDD	$17,501.00
520	POWER UNIT ASSEMBLY	5180011553840	PAHZZ	$5,491.62
521	PREAMPLIFIER,VIDEO	5895010298729	PAFDD	$316.00
522	PRE-CLEANER ASSEMBL	2590012687208	PAOOO	$2,116.00
523	PRE-CLEANER ASSEMBL	2940014087047	PBOOO	$4,553.00
524	PRECOOLER,AIR TO AI	2540011850720	PAODD	$8,483.00
525	PRINTED CIRCUIT BOARD	5999011538194	PAFDD	$1,135.00
526	PRINTED CIRCUIT BOARD	5999011578824	PAFDD	$1,405.00
527	PRINTED WIRING BOAR	5998011666128	PAFDD	$883.00
528	PRINTED WIRING BOAR	5998011894663	PAOFF	$1,629.25
529	PRINTED WIRING BOAR	5999011203753	PAFFF	$81.68
530	PRISM AND LENS ASSEMBLY TRANSMITTER	1240011195652	PADDD	$6,842.00
531	PROBE-CASE ASSEMBLY	4931013592815	PAODD	$227.00
532	PROTRACTOR,MECHANICS,PLAIN	5210013704766	PAOOO	$460.00
533	PUMP UNIT,ROTARY	4320010734289	PAOFF	$1,459.10
534	PUMP WITH CONTAINER	2520013393354	PAHDD	$29,221.00
535	PUMP, RADIAL PISTONS	4320013234923	PAHDD	$27,277.00
536	PUMP,AXIAL PISTONS	4320011428288	PAODD	$6,643.00

	NOMENCLATURE	NSN	SMRC	PRICE
537	PUMP,CENTRIFUGAL	4320011710045	PADDD	$3,991.00
538	PUMP,CENTRIFUGAL	4320012847095	PADDD	$1,230.00
539	PUMP,FUEL,ELECTRICAL	2910013414647	PAOHH	$653.00
540	PUMP,ROTARY	4320010213334	PAFDD	$1,380.00
541	PUMP,ROTARY	4320010754981	PAHDD	$144.00
542	PUMP,ROTARY	4320010777857	PAHDD	$3,346.00
543	PUMPING UNIT,HYDRAULIC,HAND DRIVEN	4320013085371	PAHHH	$1,292.00
544	PUMPING UNIT,HYDRAULIC,POWER DRIVEN	4320013389877	PAOFF	$3,834.95
545	RACE ASSEMBLY	1015011982039	PAOHH	$25,891.00
546	RACK,SPECIAL EQUIPMENT	1015011897710	PAOOO	$97.26
547	RANGEFINDER, LASER EYE SUBSYSTEM WITH CON	1240015455913	PAOLL	$29,045.00
548	RATE SENSOR ASSEMBL	6110000688409	PAODD	$5,948.00
549	READER,PUNCHED TAPE	7025013031493	PAOFD	$5,264.12
550	REAL TIME CLOCK	5999011863242	PADDD	$2,864.00
551	RECEIVER SUBASSEMBLY, RADAR	5840012736064	PADDD	$14,856.00
552	RECEIVER,INFRARED	5855014804876	PAODD	$10,574.00
553	RECEIVER-TRANSMITTE	5821011699325	PAFDD	$34,566.00
554	RECOVERY-RECHARGER	4210014889655	PAOFD	$9,700.00
555	REDUCTION GEARBOX W	2835011787246	PAFDD	$46,905.00
556	REGULATOR ASSEMBLY,VOLTAGE	6110012801801	PADDD	$902.00
557	REGULATOR,VOLTAGE	6110012550889	PAODD	$2,748.00
558	RELAY ASSEMBLY	5945012865700	PAOFF	$1,271.00
559	REMOVER,BEARING AND BUSHING	5120012017871	PAFFF	$550.00
560	REMOVER-INSTALLER,ROAD WHEEL	5120011320880	PAOOO	$903.00
561	REPAIR KIT,CONDENS	2540013777820	PAOFD	$3,597.00
562	REPAIR KIT,CRADLE	1015012904741	PAFFD	$6,397.00
563	REPAIR KIT,ELEVATIO	4933011439377	PAHHH	$3,044.00
564	RESISTOR,THERMAL	5905012185936	PAOOO	$914.22
565	RESOLVER,ELECTRICAL	5990010766858	PAFHD	$2,581.00
566	RESOLVER,ELECTRICAL	5990010781294	PADZZ	$5,556.13
567	RESOLVER,ELECTRICAL	5990010839013	PAHHH	$1,057.00
568	RETAINER ASSEMBLY	1015121921621	PAOOO	$305.00
569	RETAINER ASSEMBLY,B	2520010841225	PAHHH	$67.09
570	RETAINER,PACKING	5330011931834	PAOFF	$183.00
571	RETICLE AND HOUSING	1240010761806	PADDD	$547.00
572	RETICLE ASSEMBLY,OP	1240012602296	PAFDD	$2,495.00
573	RETICLE ASSEMBLY,OP	1240013671317	PAFDD	$1,553.00
574	RETICLE ASSEMBLY,OP	1240013772607	PADZZ	$6,058.80
575	RHNB TEST SET,ELECT	6625015098856	PAODD	$7,823.00
576	RING ASSEMBLY,HANGI	2520013283433	PADDD	$3,396.00
577	RING ASSEMBLY,UNISO	2835010743443	PADDD	$777.00
578	RING,RETAINING,OPTI	1240010787741	PAOFF	$96.32
579	ROLLER ASSEMBLY	1015012838628	PAOOO	$52.62
580	ROOF PLATE ASSEMBLY	5340013332574	PAOOO	$2,436.00
581	ROTOR, TURBINE, NONAIRCRAFT GAS TURBINE ENG	2835011313724	PADDD	$13,482.00

	NOMENCLATURE	NSN	SMRC	PRICE
582	ROTOR,GUN MOUNT	1015012032735	PBFFF	$8,125.00
583	ROTOR,MOTOR	6105011632061	PADZZ	$7,982.44
584	ROTOR,TURBINE,NONAI	2835010729961	PADDD	$8,651.00
585	ROTOR,TURBINE,NONAI	2835010743454	PBDDD	$10,097.00
586	ROTOR,TURBINE,NONAI	2835012329702	PADDD	$5,774.00
587	SAFETY SWITCH ASSEMBLY	1015012367371	PAOFF	$221.00
588	SCANNER,MECHANICAL	1240012720975	PAFDD	$16,512.00
589	SCANNER,MECHANICAL	5855010524956	PADDD	$6,105.00
590	SCREW ASSEMBLY,PANEL	5305012861738	PADHH	$128.00
591	SCROLL HOUSING,AIRCRAFT COOLING TURBINE	1660011858241	PBDDD	$299.00
592	SEAL, ASSEMBLY	2835010743447	PADDD	$349.00
593	SEAT ASSEMBLY	1015012173789	PAOOO	$297.00
594	SEAT,BALL SOCKET	2530013644956	PADDD	$63.76
595	SENSOR,SCAN POSITION	1240010787623	PADDD	$6,343.00
596	SERVICE KIT,GUN AND	1015012103709	PAFFF	$859.00
597	SERVOMECHANISM,ELEV	1265010783843	PAFDD	$16,480.00
598	SERVOVALVE,HYDRAULI	4810010766739	PAODD	$7,685.00
599	SHAFT ASSY,SHOULDER	2520010734119	PAHHH	$659.86
600	SHAFT,SHOULDERED	3040010730744	PADDD	$2,246.00
601	SHAFT,SHOULDERED	3040011192774	PADDD	$249.00
602	SHAFT,TURBINE,NONAI	2835010738002	PADDD	$1,332.00
603	SHIELD ASSEMBLY,NO	2835011602609	PADDD	$1,072.00
604	SHIFT CONTROL ASSY	2520011428251	PAOFF	$2,263.00
605	SHIPPING AND STORAG	8145011126582	PAFDD	$5,864.00
606	SHIPPING AND STORAG	8145011586804	PAFFF	$165.00
607	SHIPPING AND STORAG	8145012511903	PBFHH	$10,447.00
608	SHIPPING AND STORAG	8145014688245	PAFFF	$996.00
609	SHIPPING AND STORAGE CONTAINER,FINAL DRIVE	8145011259717	PAODD	$1,821.00
610	SHIPPING AND STORAGE CONTAINER,MISC. EQUIP.	8145015339929	PAOHH	$1,119.41
611	SHIPPING AND STORAGE CONTAINER,TRANSMISSION	8145013422875	PAHHD	$2,403.00
612	SHIPPING AND STORAGE,ENGINE	8145011126575	PBFDD	$1,336.00
613	SHIPPING AND STORAGE,ENGINE	8145011131181	PBFDD	$1,233.00
614	SHIPPING AND STORAGE,POWER SUPPLY	8145011586805	PAFFF	$117.00
615	SHOCK ABSORBER,DIRECT ACTION	2510011799181	PAOFH	$1,689.88
616	SHROUD ASSEMBLY,OUT	2835010743444	PADDD	$1,273.00
617	SHROUD SEGMENT,TURBINE,NONAIR	2835010740008	PADDD	$161.00
618	SIGHT EXTENSION,COMMANDERS ASSY	1230010777584	PAODD	$3,720.00
619	SIGHT UNIT	1240015384215	PAFDD	$66,482.00
620	SKIRT,FENDER	2510011662046	PAODD	$8,474.00
621	SLING ASSEMBLY,GEAR	4910011272711	PAFFF	$829.93
622	SLING,ENGINE AND TR	4910010866837	PAOOO	$998.00
623	SLING,MULTIPLE LEG	3940011290409	PAFFF	$256.61
624	SLIP RING ASSEMBLY	1015010748958	PAFDD	$6,262.00
625	SLIP RING ASSEMBLY	1015014617208	PAODD	$13,805.00
626	SOLENOID,ELECTRICAL	5945010845219	PBDDD	$214.00

	NOMENCLATURE	NSN	SMRC	PRICE
627	SPACER,SPECIAL SHAP	5365014112486	PAOOO	$551.19
628	SPECIAL TOOLS,FIRE	1230012394877	PAHHH	$81,339.00
629	SPECIAL TOOLS,ORGANIZATIONAL SET	5180012977811	PAOOO	$6,710.00
630	SPINDLE,WHEEL,DRIVING-NONDRIVING	2530013599499	PBDDD	$104.88
631	STAND,MAINTENANCE,AUTOMOTIVE ENGINE	4910011285509	PAHHH	$1,307.20
632	STARTER,ENGINE,GAS TURBINE	2990012765733	PAOFF	$978.00
633	STEERING ASSY,THROT	2520011805552	PAOOO	$8,704.00
634	STOP LIGHT-TAILLIGHT,VEHICULAR	6220013259836	PAOFF	$192.42
635	STOP,FIELD OF VIEW	1240010787615	PBFFF	$83.59
636	SUPPORT ASSEMBLY	4910012856065	PAFFF	$1,124.70
637	SUPPORT ASSEMBLY,CO	2835012489627	PADDD	$325.00
638	SUPPORT ASSEMBLY,PI	2520012056001	PADDD	$16,078.00
639	SUPPORT,PRINTED WIR	2590010866782	PAFFF	$111.00
640	SUPPORT,PRINTED WIR	2590011975486	PAFFD	$3,008.00
641	SUPPORT,RESEVOIR	2590011494004	PAOOO	$349.00
642	SWITCH ASSEMBLY	5930015000581	PAOZZ	$5,567.00
643	SWITCH,ELECTRONIC	5930014069318	PAOFF	$5,887.00
644	SWITCH,PRESSURE	5930011893583	PAHHH	$302.00
645	SWITCH,PROXIMITY	5930012167077	PAOOO	$712.09
646	SWITCH,THERMOSTATIC	5930012142650	PAOOO	$445.86
647	SWITCHBOARD,FIRE CONTROL	1290011264268	PAOFF	$749.00
648	SWITCHBOARD,FIRE CONTROL	1290011909769	PAFFF	$1,577.00
649	SYNTHESIZER,ELECTRI	5821011126049	PAODD	$33,373.00
650	SYNTHESIZER,ELECTRI	5895011316154	PAHDD	$8,962.56
651	TANK,FUEL,ENGINE	2910010833120	PAOOO	$1,512.39
652	TANK,FUEL,ENGINE	2910010835621	PAOOO	$455.80
653	TANK,FUEL,ENGINE	2910011381161	PAOOO	$955.49
654	TANK,FUEL,ENGINE	2910011404306	PBDDD	$2,581.00
655	TANK,LUBRICATING OIL,NONAIR	2835010743788	PBODD	$4,910.00
656	TANK,OIL,HYDRAULIC SYSTEM	2590011428249	PAOOO	$2,090.00
657	TELESCOPE SUBASSEMB	1240012713860	PAFFD	$11,360.00
658	TELESCOPE,STRAIGHT	1240010761794	PADDD	$4,855.00
659	TELESCOPE,SUBASSEMBLY	1240010761805	PADDD	$978.00
660	TENSION DEVICE,TRAC	2530013458888	PAOHH	$970.00
661	THERMAL RECEIVER	5999015370277	PAOLL	$116,180.00
662	THERMAL RECEIVER WI	1240012939706	PAODD	$75,574.00
663	TOWBAR,MOTOR VEHICLE	2540011290407	PAFFF	$411.01
664	TRANSDUCER,PRESSURE	5825011859048	PAFDD	$2,253.00
665	TRANSMISSION,HYDRAU	2520014654317	PAFHD	$178,089.00
666	TRANSMITTER,LASER	1240012616045	PADDD	$4,320.00
667	TRAP,MOISTURE	4730012150498	PAODD	$1,950.00
668	TUBE ASSEMBLY,AMMO	4710011978091	PAOOO	$1,375.62
669	TUBE ASSEMBLY,AMMUNITION RACK	1015012033356	PAOOO	$2,771.00
670	TUBE ASSEMBLY,METAL	4710012922996	PBDDD	$1,464.00
671	TUBE,CANNON	1015012128575	PAFZA	$94,336.00

	NOMENCLATURE	NSN	SMRC	PRICE
672	TUBING ASSEMBLY,NON	4710013312885	PAOOO	$1,766.00
673	TURNOVER STAND,FINA	4910012260554	PAFZZ	$6,304.00
674	VALVE ASSEMBLY	4820014068170	PAOOO	$8,030.00
675	VALVE ASSEMBLY,POPPET,HULL DRAIN	2590007525962	PAOOO	$65.36
676	VALVE ASSY,SIGNAL,P	2520010737703	PAHDD	$175.00
677	VALVE BODY ASSY,T	2520010737705	PAHDD	$292.00
678	VALVE HEAD,HYDRAULIC MOTOR-PUMP	4320012056041	PADDD	$2,088.00
679	VALVE,BUTTERFLY	4820010743662	PAODD	$639.00
680	VALVE,CHECK	4820012215864	PAOZZ	$5,052.93
681	VALVE,FUEL PRESSURIZING AND DR	2915011404266	PADDD	$141.00
682	VALVE,LINEAR,DIRECT	2520011475821	PADDD	$1,310.00
683	VALVE,LINEAR,DIRECT	4810010733066	PADZZ	$9,651.40
684	VALVE,LINEAR,DIRECT	4810010915464	PADDD	$3,674.00
685	VALVE,LINEAR,DIRECT	4810012003109	PAODD	$1,908.00
686	VALVE,LINEAR,DIRECT	4810012008499	PAHDD	$656.00
687	VALVE,LINEAR,DIRECT	4810012014843	PAHDD	$1,092.00
688	VALVE,LINEAR,DIRECT	4810012056046	PADDD	$1,353.00
689	VALVE,LINEAR,DIRECT	4810012461173	PAODD	$2,049.00
690	VALVE,LINEAR,DIRECT	4810012632541	PADDD	$1,315.00
691	VALVE,LINEAR,DIRECT	4820013081858	PAODD	$4,109.00
692	VALVE,LINEAR,DIRECT	4820013967094	PAOHD	$900.00
693	VALVE,REGULATING,FLUID PRESSURE	4810012499708	PAOHH	$2,184.00
694	VALVE,REGULATING,SYSTEM PRESSURE	4820011879611	PAOHH	$4,041.52
695	VALVE,REGULATING,TEMPERATURE	4820013776818	PAODD	$3,863.00
696	VALVE,RELIEF,PRESSU	4820012093479	PADDD	$206.00
697	VALVE,SOLENOID	4810011303604	PADDD	$1,028.00
698	VANE SEGMENT,FAN,NO	2835010871111	PADDD	$1,046.00
699	VENTILATOR,AIR CIRCULATING	2540012006206	PAOOO	$198.00
700	VIEWER,INFRARED	5855014759446	PAODD	$10,769.00
701	VIEWER,NIGHT VISION	5855010960872	PAODD	$5,731.00
702	WHEEL,SOLID RUBBER TIRE	2530012014816	PAOOD	$663.00
703	WHEEL,SOLID,METALLIC	5340010635825	PAOOO	$704.51
704	WINDOW,OPTICAL INST	1240012187328	PAFDD	$4,802.00
705	WIRING HARNESS	2920010991535	PAOFF	$271.00
706	WIRING HARNESS	6150010729986	PAFFF	$417.00
707	WIRING HARNESS	6150010835476	PBOFF	$659.00
708	WIRING HARNESS	6150011015051	PAOFF	$183.02
709	WIRING HARNESS	6150011194113	PAOFF	$431.00
710	WIRING HARNESS	6150011194115	PAOFF	$1,221.00
711	WIRING HARNESS	6150011194116	PAOFF	$336.00
712	WIRING HARNESS	6150011194117	PAOFF	$502.00
713	WIRING HARNESS	6150012005941	PAOFF	$1,562.00
714	WIRING HARNESS	6150012014799	PAOFF	$794.00
715	WIRING HARNESS	6150013914929	PAOFF	$930.00
716	WIRING HARNESS	6150013914932	PAOFF	$272.00

	NOMENCLATURE	NSN	SMRC	PRICE
717	WIRING HARNESS	6150013918453	PAFFF	$144.00
718	WIRING HARNESS	6150013933724	PAOFF	$515.00
719	WIRING HARNESS	6150013937048	PAOFF	$176.00
720	WIRING HARNESS	6150015280672	PAOLL	$4,066.30
721	WIRING HARNESS	6150015281033	PAOLL	$1,742.70
722	WIRING HARNESS,BRAN	2590010835722	PAOFF	$427.00
723	WIRING HARNESS,BRAN	2590010835723	PAOFF	$410.00
724	WIRING HARNESS,BRAN	2590011170636	PAFFF	$536.00
725	WIRING HARNESS,BRAN	2590011170637	PAHHH	$1,691.00
726	WIRING HARNESS,BRAN	2590011170638	PAHHH	$1,489.00
727	WIRING HARNESS,BRAN	2590011194114	PAOFF	$600.00
728	WIRING HARNESS,BRAN	2590011285744	PAFHH	$365.00
729	WIRING HARNESS,BRAN	2590012011144	PAFFF	$550.00
730	WIRING HARNESS,BRAN	2920010675407	PAOFF	$399.00
731	WIRING HARNESS,BRAN	2920010729989	PAFFF	$102.00
732	WIRING HARNESS,BRAN	2920011645899	PAFDD	$2,136.00
733	WIRING HARNESS,BRAN	4810012926557	PAFDD	$1,342.00
734	WIRING HARNESS,BRAN	5995010730142	PAOFF	$139.00
735	WIRING HARNESS,BRAN	5995011799303	PAFFF	$2,034.00
736	WIRING HARNESS,BRAN	5995011897722	PAOFF	$414.00
737	WIRING HARNESS,BRAN	5995011924082	PAOFF	$1,047.00
738	WIRING HARNESS,BRAN	5995011975555	PAOFF	$1,337.00
739	WIRING HARNESS,BRAN	5995011992410	PAFFF	$444.00
740	WIRING HARNESS,BRAN	5995011992411	PAOFF	$324.00
741	WIRING HARNESS,BRAN	5995011992413	PAHHH	$134.86
742	WIRING HARNESS,BRAN	5995011995537	PAOFF	$1,651.00
743	WIRING HARNESS,BRAN	5995011995538	PAFFF	$827.00
744	WIRING HARNESS,BRAN	5995012006223	PAOFF	$130.00
745	WIRING HARNESS,BRAN	5995012018055	PAOFF	$472.00
746	WIRING HARNESS,BRAN	5995012018056	PAOFF	$564.00
747	WIRING HARNESS,BRAN	5995012042606	PAFFF	$1,641.00
748	WIRING HARNESS,BRAN	5995012056039	PAFFF	$1,059.00
749	WIRING HARNESS,BRAN	5995013922174	PAOFF	$1,026.00
750	WIRING HARNESS,BRAN	5995013922176	PAOFF	$879.00
751	WIRING HARNESS,BRAN	6150010730133	PAOFF	$498.00
752	WIRING HARNESS,BRAN	6150010749015	PAOFF	$497.00
753	WIRING HARNESS,BRAN	6150010766878	PAOFF	$958.00
754	WIRING HARNESS,BRAN	6150010766884	PAOFF	$580.00
755	WIRING HARNESS,BRAN	6150010781217	PAFFF	$356.00
756	WIRING HARNESS,BRAN	6150011894711	PAFFF	$144.00
757	WIRING HARNESS,BRAN	6150011897727	PAOFF	$406.00
758	WIRING HARNESS,BRAN	6150012664011	PAOFF	$1,717.00
759	WIRING HARNESS,BRAN	6150013264708	PAOFF	$307.67
760	WIRING HARNESS,BRAN	6150013908589	PAOFF	$822.00
761	WIRING HARNESS,BRAN	6150013911052	PAOFF	$433.00

	NOMENCLATURE	NSN	SMRC	PRICE
762	WIRING HARNESS,BRAN	6150013911053	PAOFF	$779.00
763	WIRING HARNESS,BRAN	6150013911058	PAOFF	$759.00
764	WIRING HARNESS,BRAN	6150013920065	PAOFF	$816.00
765	WIRING HARNESS,BRAN	6150013933723	PAOFF	$2,044.00
766	WIRING HARNESS,BRAN	6150013933725	PAOFF	$575.00
767	WIRING HARNESS,BRAN	6150013933726	PAOFF	$1,029.00
768	WIRING HARNESS,BRAN	6150013941713	PAOFF	$755.00
769	WIRING HARNESS,BRAN	6150014068166	PAOFF	$424.00
770	WIRING HARNESS,BRAN	6150014068168	PAOFF	$1,471.00
771	WIRING HARNESS,BRAN	6150014222561	PAOFF	$1,209.00
772	WIRING HARNESS,BRAN	6150015307391	PAOLL	$1,742.70
773	WRENCH SET,CROWFOOT,RATCHETING	5120011177855	PAOOO	$455.40
774	WRENCH SET,SPANNER	5120012042693	PAFFF	$1,464.00
775	YOKE AND COVER ASSEMBLY,MATCHED	1015011195656	PAHHH	$219.00

2003 - 2008 Sponsored Research Topics

Acquisition Management

- Acquiring Combat Capability via Public-Private Partnerships (PPPs)
- BCA: Contractor vs. Organic Growth
- Defense Industry Consolidation
- EU-US Defense Industrial Relationships
- Knowledge Value Added (KVA) + Real Options (RO) Applied to Shipyard Planning Processes
- Managing Services Supply Chain
- MOSA Contracting Implications
- Portfolio Optimization via KVA + RO
- Private Military Sector
- Software Requirements for OA
- Spiral Development
- Strategy for Defense Acquisition Research
- The Software, Hardware Asset Reuse Enterprise (SHARE) repository

Contract Management

- Commodity Sourcing Strategies
- Contracting Government Procurement Functions
- Contractors in 21st Century Combat Zone
- Joint Contingency Contracting
- Model for Optimizing Contingency Contracting Planning and Execution
- Navy Contract Writing Guide
- Past Performance in Source Selection
- Strategic Contingency Contracting
- Transforming DoD Contract Closeout
- USAF Energy Savings Performance Contracts
- USAF IT Commodity Council
- USMC Contingency Contracting

Financial Management

- Acquisitions via leasing: MPS case
- Budget Scoring
- Budgeting for Capabilities Based Planning
- Capital Budgeting for DoD
- Energy Saving Contracts/DoD Mobile Assets
- Financing DoD Budget via PPPs
- Lessons from Private Sector Capital Budgeting for DoD Acquisition Budgeting Reform
- PPPs and Government Financing
- ROI of Information Warfare Systems
- Special Termination Liability in MDAPs
- Strategic Sourcing
- Transaction Cost Economics (TCE) to Improve Cost Estimates

Human Resources

- Indefinite Reenlistment
- Individual Augmentation
- Learning Management Systems
- Moral Conduct Waivers and First-tem Attrition
- Retention
- The Navy's Selective Reenlistment Bonus (SRB) Management System
- Tuition Assistance

Logistics Management

- Analysis of LAV Depot Maintenance
- Army LOG MOD
- ASDS Product Support Analysis
- Cold-chain Logistics
- Contractors Supporting Military Operations
- Diffusion/Variability on Vendor Performance Evaluation
- Evolutionary Acquisition
- Lean Six Sigma to Reduce Costs and Improve Readiness

- Naval Aviation Maintenance and Process Improvement (2)
- Optimizing CIWS Lifecycle Support (LCS)
- Outsourcing the Pearl Harbor MK-48 Intermediate Maintenance Activity
- Pallet Management System
- PBL (4)
- Privatization-NOSL/NAWCI
- RFID (6)
- Risk Analysis for Performance-based Logistics
- R-TOC Aegis Microwave Power Tubes
- Sense-and-Respond Logistics Network
- Strategic Sourcing

Program Management

- Building Collaborative Capacity
- Business Process Reengineering (BPR) for LCS Mission Module Acquisition
- Collaborative IT Tools Leveraging Competence
- Contractor vs. Organic Support
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to Aegis and SSDS
- Managing the Service Supply Chain
- Measuring Uncertainty in Eared Value
- Organizational Modeling and Simulation
- Public-Private Partnership
- Terminating Your Own Program
- Utilizing Collaborative and Three-dimensional Imaging Technology

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